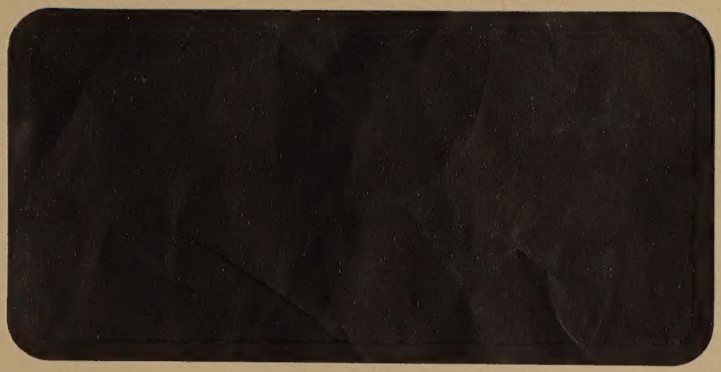
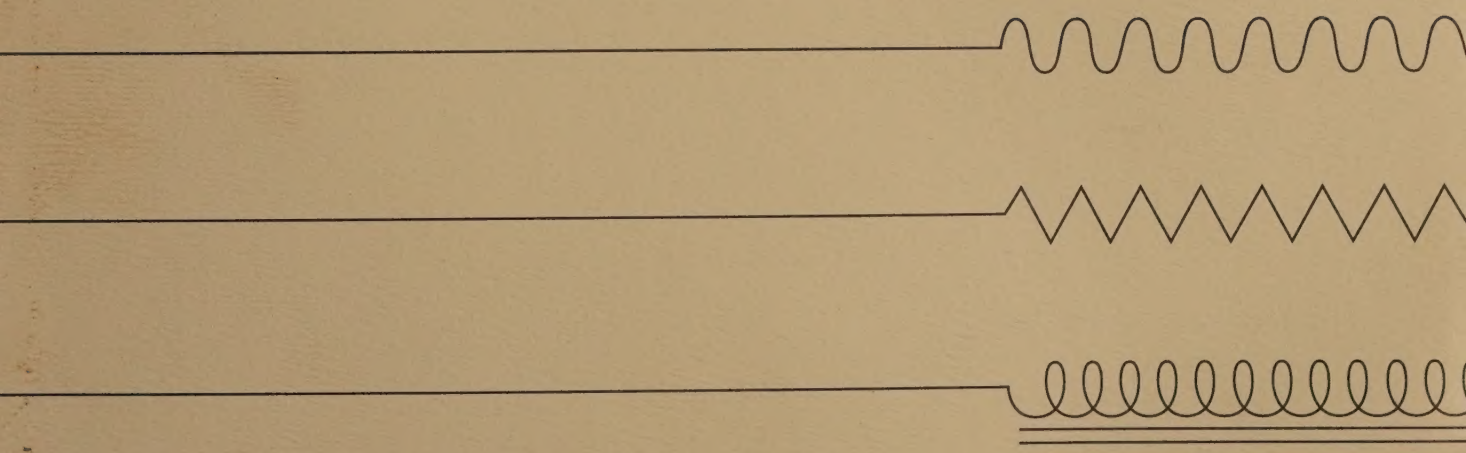
Measurements International





HIGH RESISTANCE RATIO BRIDGE

MODEL 6000A

OPERATING MANUAL

6000A.OM Rev.6

97-11-20

S/N: 951003

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1 Introduction

1.1 Scope

This manual contains operating instructions on the Model 6000A Automated High Resistance Ratio Bridge.

1.2 General Description

The technology of the Model 6000A Automatic High Resistance Ratio Bridge is based on the switching technique for binary resistive voltage dividers designed by R.D. Cutkosky (NIST). This technology was implemented by Dr. S. Hoi Tsao of the National Research Council of Canada to a microprocessor controlled self-balancing ratio bridge and has been extended by Measurements International to a self-balancing resistance ratio bridge.

The Model 6000A was engineered to provide an easy means of establishing the ratio of two resistors and to assign a value to the unknown resistor based on the value of the standard resistor. Ratio measurements up to 1000:1 can be performed. A 5½ digit DVM is used as a differential detector to obtain a systems resolution of 8 digits over the range of 1 KΩ to 1 GΩ.

The Model 6000A Automated High Resistance Bridge has the capability of:

- self-calibrating in terms of divider linearization
- measuring ratios of 1:1 to 1000:1
- assigning values to any of its inputs
- providing 8 digits of accuracy with an uncertainty of 1 part per million (ppm) or better

Four 4-terminal resistors may be connected to the inputs of the Model 6000A. The selection of resistors may be extended to 40 with the addition of two of Measurements International's Model 4220A Four Terminal Matrix Scanners to provide flexibility in resistor intercomparisons.

Resistor inputs can be selected by front panel selection or via the IEEE488 interface bus. Front panel LEDs indicate the resistor selected. However, all measurement data, either self-calibration or voltage measurement, is transmitted over the bus.

Furthermore, the Model 6000A is fully automatic and is calibrated without manual intervention. There are no internal adjustments and, as the Model 6000A is a ratio device, *"true"* self-calibration can be performed.

Figure 1 displays a functional drawing of the Model 6000A. The right-hand side has two resistors marked **HI** and **LO**, which correspond to the upper and lower resistors. Also, the potential points marked **P1** and **P2** for each resistor are used in the measurement sequence.

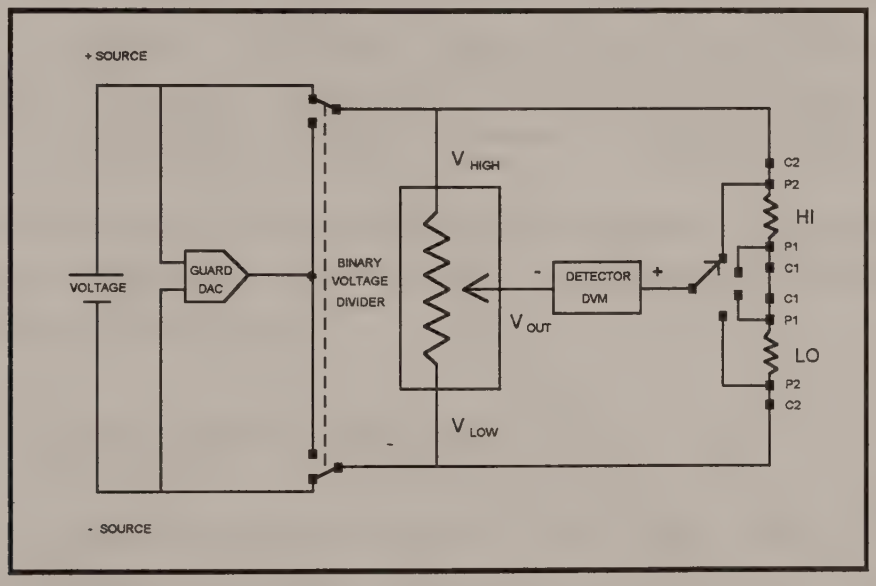


Figure 1 ... 6000A Functional Drawing

2 Setup & Connections

2.1 Setup

2.1.1 Hardware Requirements

The computer should be at least a 386 computer running Windows 3.1 or Windows 95. A minimum of 4 M of RAM is required with less than 2 M of hard disk space. A colour monitor and mouse is also essential.

For the IEEE interface, an IOTECH Personal 488 interface card (8-bit) is required and must be installed in the computer. Although, there are various models of this interface card, we recommend the Model AT488 or GP488B. GPIB cables are also required to connect the computer to the instruments used in the 6000A system.

The 6000A system may be operated in several configurations. The equipment supported by the software is listed in Section 3.1.2 of this manual and is described further throughout the manual.

2.1.2 IEEE488 Hardware Configuration

Before loading the Model 6000A Software, an IOTECH Personal 488 interface card must be installed in the computer. Modify the jumper selections on the interface card as follows (refer to the IOTECH IEEE488 Manual):

- Interface Base Address: 02E1
- DMA Channel: None
- Interrupt (IRQ) None
- Wait States: None

For the IEEE488 software configuration, refer to Section 3.1.2.

2.1.3 6000A Software Installation

NOTE: The Model 6000A Software is provided under an exclusive license and is for use only with the system it was supplied with.

Before loading the Model 6000A Software, the **IOTECH DRIVER488 / WIN** software must be loaded on the computer. These instructions are located in the IOTECH manual entitled *"Installing Driver488 / WIN on your System"*. If a DOS version of the Driver was previously loaded on the system, then it must be removed from the *"autoexec.bat"* file as the two drivers may conflict with each other. Ensure that the computer is rebooted.

With the IEEE488 Driver loaded successfully, insert the 6000A Software Setup Disk and type **"a:setup"** from the Windows Program Manager to install the 6000A Software. The setup procedure will allow the user to install the software to a specific directory or the default directory (**c:\6000A**). Once the software installation is complete, the message *"6000A Software loaded successfully"* will appear and an icon will be created in the Windows Program Manager entitled **"MIL 6000A Software"**.

NOTE: If an error occurs with loading a specific file, that file may already exist for another application. To correct this problem, rename the existing file and repeat the 6000A Software installation procedure.

2.1.4 Running the 6000A Software

To run the 6000A Software, click the mouse on the **"MIL 6000A Software"** icon in Windows and the Opening Menu Screen will be displayed as illustrated in Figure 3. Sample files have been included for the Setup, Resistor, and Program files as a tool to gain familiarity with the software.

NOTE: Please ensure that no other Windows program is running in the background when running the MIL 6000A Software as other programs may conflict with the 6000A Software.

2.2 Rear Panel

Figure 2 shows a drawing of the rear panel of the Model 6000A.

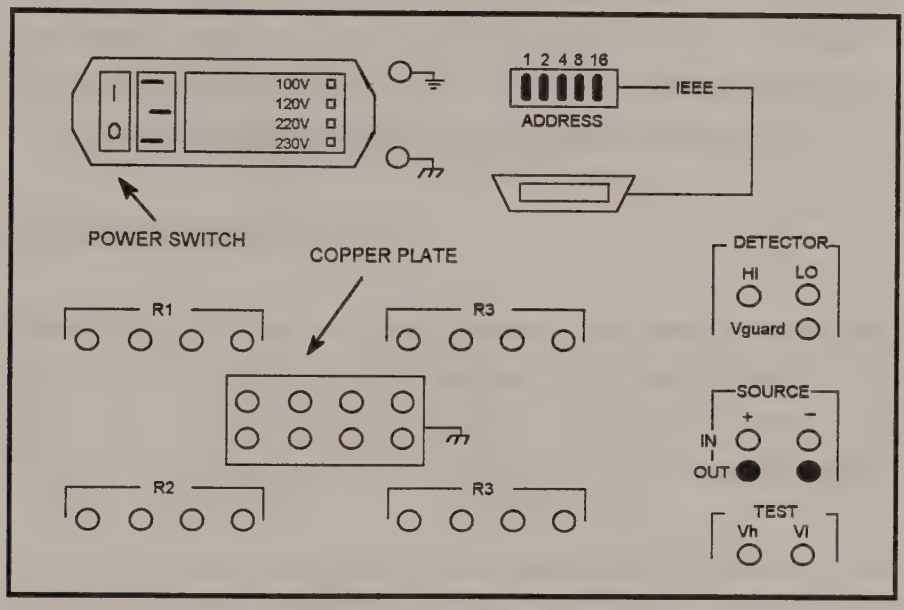


Figure 2 ... 6000A Rear Panel

2.2.1 Power Switch

The power switch is located on the power entry module on the rear of the Model 6000A (refer to Figure 2). When the switch is in the *"ON"* position, the **POWER** LED indicator on the front panel is illuminated.

Before applying power to the Model 6000A, check that the rear panel line voltage selector is set to the nominal line voltage in your area. Refer to the Installation section of the Model 6000A Technical Manual if the voltage is incorrect.

2.2.2 Input Connections

Resistors are connected in a four wire configuration with the current leads being connected to the C_1 and C_2 terminals and the potential leads connected to the P_1 and P_2 terminals respectively. The shields of the low thermal leads are connected to the ground plate on the rear of the Model 6000A.

> **NOTE: When interfacing to a MIL Matrix Scanner (Model 4210A or 4220A), the A and B outputs of the scanner must be connected to the Model 6000A R_1 and R_2 inputs respectively. To connect a second MIL scanner, the A and B outputs of this scanner must be connected to the Model 6000A R_3 and R_4 inputs respectively.**

Other input connections are as follows:

- **COPPER PLATE:** The copper plate is connected to chassis or earth ground through the third pin of the AC Receptacle. This plate is used to tie the shields of the low thermal resistor leads to chassis ground. Shielded leads should be used for connecting the resistors to the rear of the Model 6000A.

- **DETECTOR:** The Detector (DVM) is connected to the **DETECTOR** terminals designated **HI** and **LO**, where **HI** connects to DVM positive and **LO** connects to DVM negative.

- **VGUARD:** Vguard is an active driven, low impedance output. This output is used to drive the guard of a guarded detector. When not using a guarded detector, the screen of the detector lead should be tied to the ground plate of the Model 6000A.

- **SOURCE INPUT:** An isolated, low noise voltage source of 10 V to 19.999 V is connected to the **SOURCE IN ±** terminals.

WARNING: The source voltage must be less than 20 V to prevent the DVM from auto ranging to the 20 V range. The 20 V range on most DVMs has a much lower input impedance, which in turn causes the Model 6000A to overload and lock up.

When using two MIL Model 1000 DC Sources, one of the units must be adjusted to 9.999 V_{DC}. If two DC Sources were ordered to be used with the Model 6000A, this adjustment would have been done in the factory. When using a locally supplied source, the voltage must be adjusted to 19.999 V_{DC}.

- **SOURCE OUTPUT:** Not used.

- **TEST:** This is used to access the top (V_H) and bottom (V_L) of the source voltage through the divider for testing purposes.

- **INTERFACE CONNECTIONS:** The Model 6000A is compatible with the IEEE-488 1978 standard. Interface connection is made via the 24-pin connector located on the rear panel of the unit. Commands sent on the interface bus control the relay switching to select the input channel and set the required ratios for calibration and measurement ratios.

2.2.3 Address Selection

The address on the Model 6000A is determined by the setting of the **ADDRESS** select switch located on the rear panel of the unit and is read at power-on. The factory preset address is **"14"** for the Model 6000A and **"23"** for the DVM detector. Refer to Section 3.1.2 for device configuration.

2.3 Front Panel

Before attempting to operate the system over the interface bus, a manual check should be performed to gain familiarity with the Model 6000A. The **UPPER** and **LOWER** resistor channels may be selected by pressing the proper keys.

As a check, press the **UPPER 1** key and observe the LED indicator light illuminate. Next, press the **UPPER 2** key, observing the **UPPER 1** LED turn off and **UPPER 2** LED turn on. Step through the **UPPER** and **LOWER** resistor selections to verify that the resistor channels are functional.

> NOTE: **While stepping through the resistor selections, the UPPER 4 key remains illuminated until the LOWER 4 key is pressed. Selecting the same resistor channel on both sides will cause the resistor channel selected first to be disconnected.**

If all resistor channels are functional, press the **CLEAR** key to clear all LED indicators.

3 Software Menu Screens

3.1 Opening Menu Screen

The **Opening Menu Screen** is displayed upon entering the 6000A Software program (refer to Figure 3). This screen allows the user to load previously saved files for initial settings. These files contain customer information on previously calibrated resistors.

The lower portion of the Opening Menu Screen contains a listing of all setup (*.set), resistor (*.res), and program files (*.prg) within the working directory. To select the initial settings for the software, highlight the appropriate files using the mouse. Some sample files are given and will be displayed under the proper listing. It is also possible to change the working drive and/or directory from this menu.

Figure 3 ... Opening Menu Screen

3.1.1 Continue Key

Once the appropriate files (Setup, Resistor, and Program) have been highlighted, then selecting the **Continue** key will display the Main Menu Screen.

If any device initialization errors occur before the Main Menu Screen is displayed, they must be corrected before performing a measurement. The software checks the setup file presently highlighted for connected scanners, as well as the Mensor barometer. Should an initialization error occur for either of these devices, ensure that they are configured in the configuration file (refer to Section 3.1.2) or disable them in the Setup Menu Screen (refer to Section 3.3.1). If a bridge initialization error occurs, verify that it also is configured properly and that the address selected corresponds to the DIP switch selection on the rear of the Model 6000A unit.

Finally, if the error *"Cannot initialize IEEE488 Driver"* occurs, verify that the IOTECH interface card and IEEE488 Driver Software (for Windows) are installed, and that the settings agree (refer to Section 2.1.2 and 3.1.2).

3.1.2 Configure Key

Selecting the **Configure** key allows the user to configure the IEEE488 Driver to include other devices as well as the Model 6000A Automatic High Resistance Ratio Bridge. Other devices that may be used with the 6000A Software are:

- MIL Model 4210A Matrix Scanner (10 channel scanner)
- MIL Model 4220A Matrix Scanner (20 channel scanner)
- Fluke Model FL8842A DVM
- Hewlett Packard Model HP3458A DVM
- Datron Model DA1281 DVM
- Mensor 15000 Barometer
- Rotronic AM3 Temperature / Humidity Device (via serial port)

Figure 4 displays the IOTECH Personal 488 Configuration file. The Interface Configuration settings shown (IEEE) must match the hardware configuration of the IEEE488 Driver interface card as follows:

- Interface Type: AT488 or GP488B
- Interface Base Address: 02E1
- IEEE Bus Address: 21
- DMA Channel: None
- Interrupt: None

Also, under Interface Configuration, the **'IN' & 'OUT' Terminators** should read **"None"** with no End Of Interrupt (ie. **EOI** should not be marked).

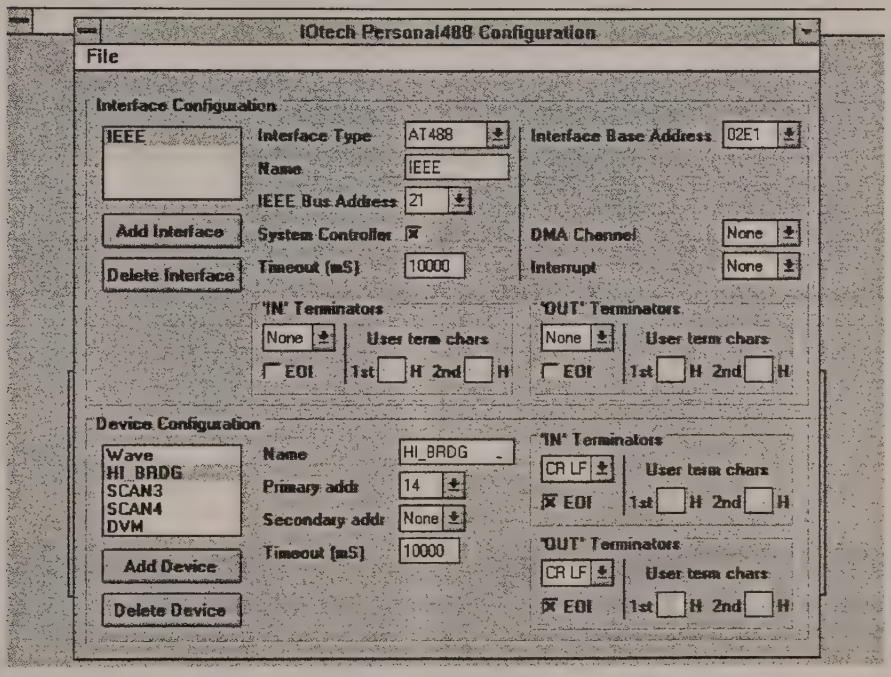


Figure 4 ... IEEE488 Configuration Screen

In order for the software to communicate with the various units, they must be addressed under Device Configuration. To add a device to the configuration file, simply select **Add Device** and enter the proper name and GPIB address. The table on page 12 of this manual shows the required information for all the devices compatible with the 6000A Software. The Primary Address of each device indicates

recommended settings and may be changed as long as the configuration matches the address setting on the device and it doesn't conflict with other devices.

Device	Device Name	Primary Address	'IN' & 'OUT' Terminators	End of Interrupt
6000A	HI_BRDG	14	CR LF	Yes
Scanner #1	SCAN3	5	CR LF	Yes
Scanner #2	SCAN4	6	CR LF	Yes
DVM	DVM	23	CR LF	Yes
Datron 1281	DVM	23	LF	Yes
Barometer	BAROMTR	8	CR LF	Yes
Dummy Device	WAVE	16	CR LF	Yes

NOTE: Once changes have been made to the IEEE488 configuration file, the 6000A Software must be restarted again.

The IEEE488 configuration file must also agree with the Setup file device selections. In other words, any units selected in the Setup file must be addressed as a device in the configuration file.

3.1.3 About Key

Selecting the **About** key gives the user information on Measurements International and the 6000A Software (refer to Figure 5). Any problems or inquiries about the software can be addressed by contacting Measurements International at the numbers shown or by using our email address.

The software version and the date it was compiled is also shown here. Refer to this version number when contacting Measurements International regarding software problems.

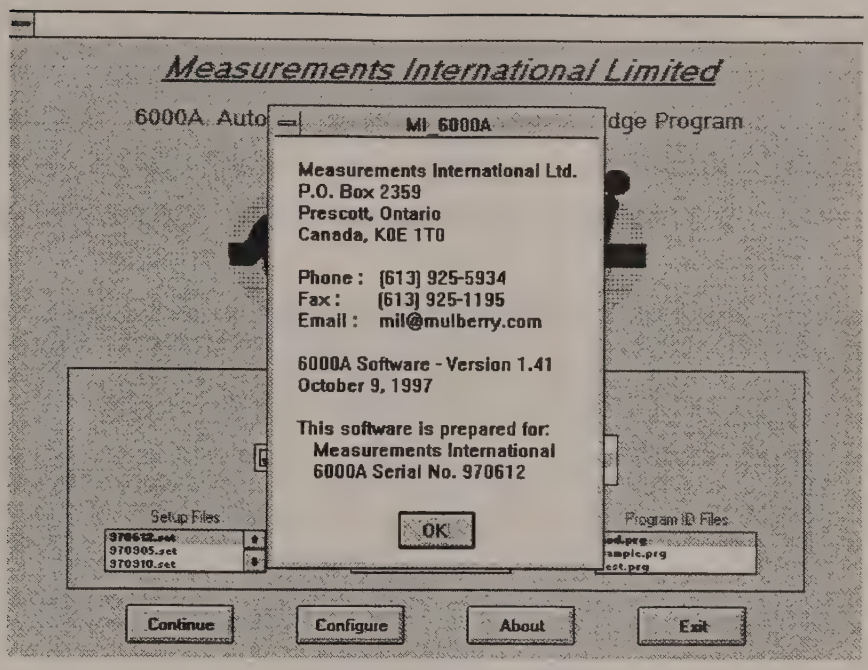


Figure 5 ... 6000A Software Information

3.1.4 Exit Key

The **Exit** key exits the MIL 6000A Software and returns the user to Windows.

3.2 Main Menu Screen

The **Main Menu Screen** allows access for system setup, calibration, resistor identification, program generation, and measurement. A group of menu keys at the top of the screen allows the user to perform a complete measurement (refer to Figure 6). These menu keys are selected by clicking the mouse on the desired key.

The remainder of the Main Menu Screen is divided into three sections. The upper portion displays a graph which plots the resistance measurements for more than one measurement. A Measurement Table, which displays the ratio measurement values, is displayed in the lower left portion of the screen. Finally, the lower right portion of the screen contains data boxes which display important information on the measurement taking place.

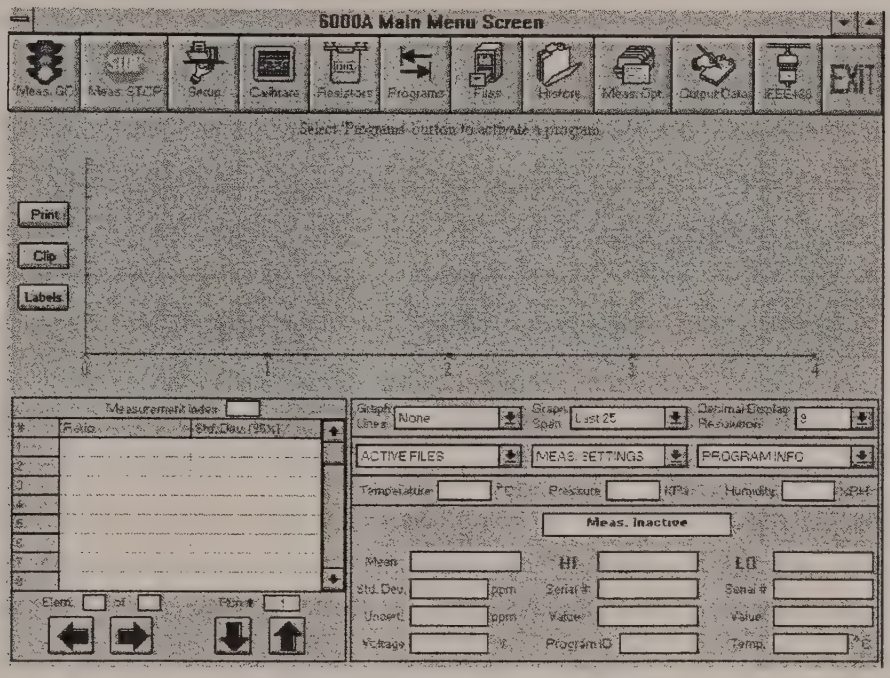


Figure 6 ... Main Menu Screen

The following gives a very brief description of the functions of the menu keys in the Main Menu Screen. These keys are described further in later sections.

- **Meas.GO** - starts a measurement run
- **Meas.STOP** - stops a measurement run
- **Setup** - contains hardware configuration and file information
- **Calibrate** - calibrates the Model 6000A
- **Resistors** - contains resistor / thermistor information
- **Programs** - selects, creates, or edits a measurement program
- **Files** - saves / loads setup, resistor, and program files
  - contains 6000A Software Operating Manual for reference

- **History** - saves / loads summary information on artifacts
- **Meas.Opt.** - includes various measurement options
- **Output Data** - outputs measurement data to Notepad or Write
  - allows user to view or edit data files
- **IEEE488** - contains IEEE488 Driver functions
- **Exit** - exits the MIL 6000A Software

As already noted, the lower portion of the screen contains relevant information based on the measurement being performed. **ACTIVE FILES**, **MEAS. SETTINGS**, and **PROGRAM INFO** use drop-down menus to reveal the pertinent data of the measurement being performed. If the Rotronic AM3 and Mensor 15000 devices are connected to the 6000A system, the **Temperature**, **Pressure**, and **Humidity** of the lab environment are displayed during a measurement. Information on the artifacts being tested are displayed in the data boxes under **HI** and **LO**.

Ratio measurement values are displayed in the Measurement Table in the lower left portion of the screen, while the resistance values are plotted in a graph in the upper portion of the screen. **Graph Lines**, **Graph Span**, and **Decimal Display Resolution** use drop-down menus and may be changed at any time, even during a measurement. The mean ratio, standard deviation, and uncertainty for these measurements are updated in their respective boxes.

Refer to Section 5 - *"Performing a Measurement"* to observe how these functions are used during a measurement run.

3.3 Setup Menu Screen

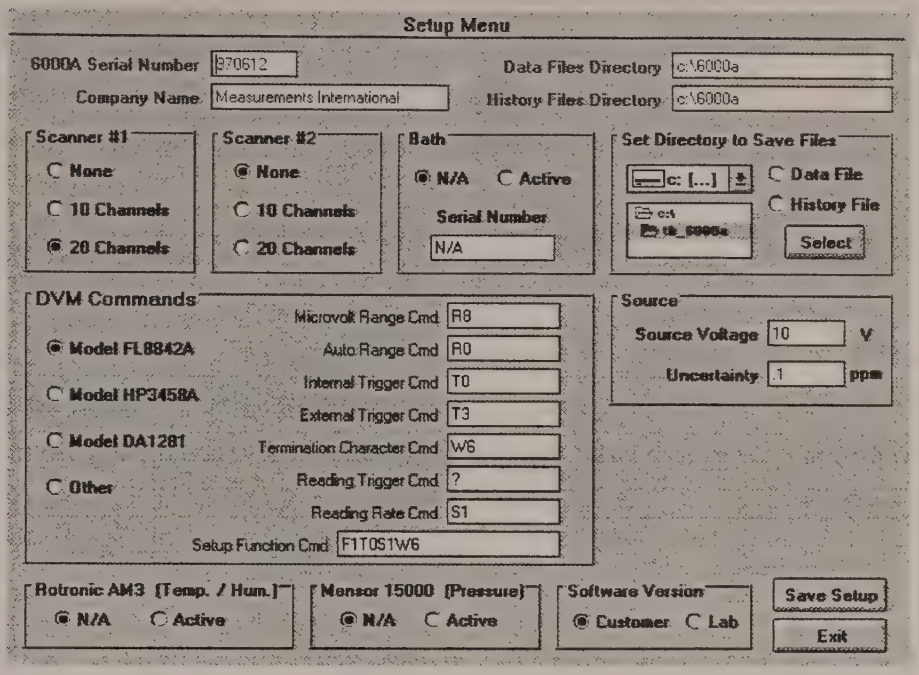


Figure 7a ... Setup Menu Screen for Fluke FL8842A DVM

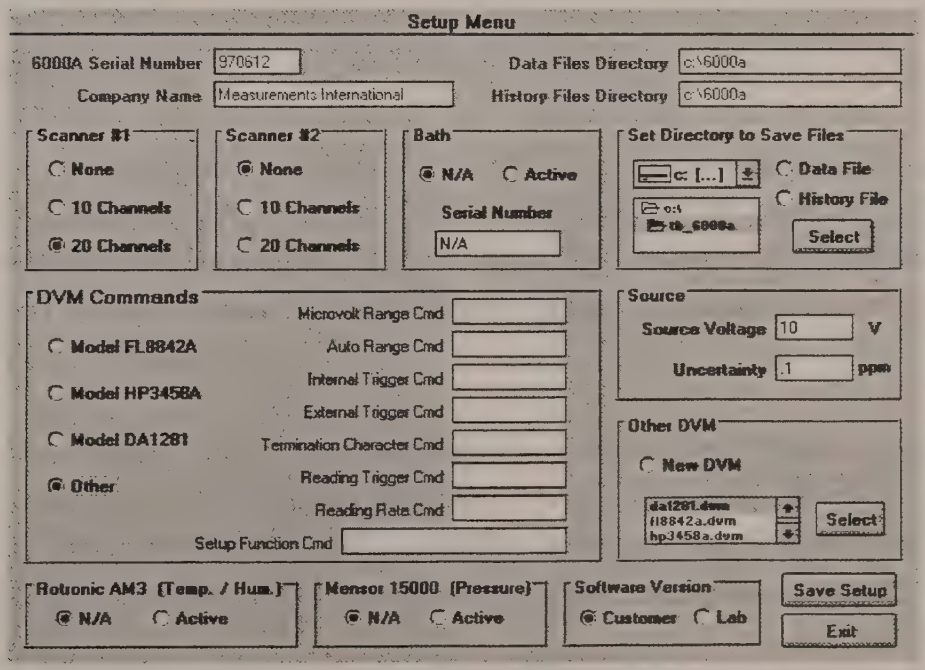


Figure 7b ... Setup Menu Screen for Other DVMs

The **Setup Menu Screen** (refer to Figures 7a & b) provide information on the software as well as the system hardware. Before calibration or measurements are performed, the **"6000A Serial Number"** and **"Company Name"** should be modified. To do so, enter the required information located in the upper left portion of the Setup Menu Screen.

3.3.1 Device Setup

Figures 7a & b display the setup for operating the Model 6000A with a 20-channel scanner connected. The system may be increased to include up to two scanners (either 10 or 20 channels). The **Source Voltage**, which is the potential applied to the SOURCE IN terminals at the rear of the Model 6000A, and its uncertainty may also be modified in the Setup Menu Screen.

To monitor the lab environment, a **Rotronic AM3** device may be connected to the system through the serial port to measure the temperature and humidity. To monitor the pressure, a **Mensor 15000** Barometer may be connected to the system via the IEEE488 interface. If these devices are made active, the temperature (°C), humidity (%RH), and pressure (Kpa) of the lab are measured during calibration and measurements.

Finally, a Bath option is displayed for performing calculations on alpha and beta coefficients of resistors. This option will be incorporated into the system in a future version of the 6000A Software and so is temporarily disabled. Any device made active in the Setup Menu Screen must be connected to the system in order for the software to function properly.

Device address changes are performed by selecting the *"Change IEEE488 Configuration"* option in the IEEE488 Menu Screen. Any device which is to be added to the system software must be addressed in the IEEE488 configuration file. For device names, refer to the table located on page 12 of this manual.

3.3.2 DVM Selection

Various DVMs may be used with the 6000A Software. The Setup Menu Screen allows the user to select a listed DVM or create a new DVM file for one that is not listed. The listed DVMs are: Fluke Model FL8842A, Hewlett Packard Model HP3458A, and Datron Model DA1281. The DVM commands for these models are already entered and are displayed when the DVM is selected (refer to Figure 7a).

NOTE: The Fluke Model FL8842A DVM may not produce accurate results when measuring at 1 GΩ.

To create a new DVM file, select **Other** under **DVM Commands**. Another box is displayed containing options to add a new DVM or select a DVM that was already created (refer to Figure 7b). To add a new DVM to the listed ones, select the **New DVM** option and enter the Model Number. Next, enter in the commands obtained from the DVM manual as prompted. If a command is not given, leave the corresponding data box blank. Once all commands have been entered, select the **Store** button to store the data to a file and add the DVM to the list. To select a DVM that was previously created, highlight the desired DVM in the list and press the **Select** key to display the corresponding commands in the appropriate data boxes.

NOTE: When selecting a new DVM to use with the 6000A Software, the input impedance must be larger than 10 GΩ. Also, a nanovolt meter cannot be used since the input offset current is too high.

3.3.3 Setup Options

The Setup Menu Screen allows the user to save Output Data files and History files to a specific drive and directory other than the current working directory. To do so, use the mouse to select the chosen drive and directory (the directory must already exist on that drive). Once the path is chosen, click on **"Data File"** or **"History File"** and then click on the **"Select"** button. The information at the top of the setup screen will automatically be updated.

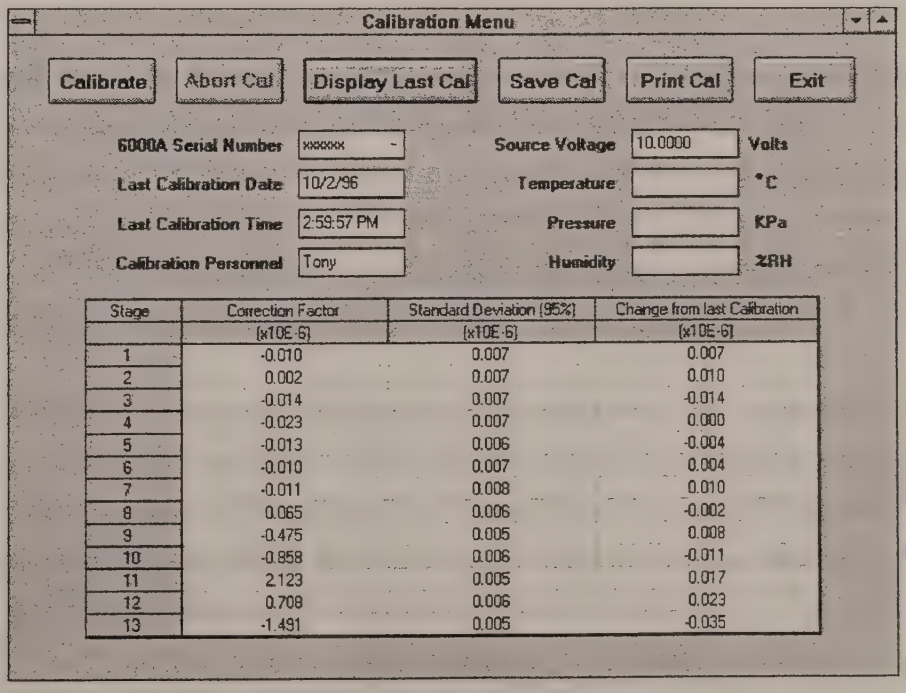
The **Software Version** option allows the user to switch between **"Customer"** mode and **"Lab"** mode. The difference is that the **"Lab"** mode prints more information during measurements and is used primarily for testing purposes.

After all selections have been made, clicking on the **"Save Setup"** button creates a setup file based on the hardware configuration. These files may be selected at any time using the **"Files"** menu button from the Main Menu Screen.

> **NOTE: Many different setup files may be created. It may be advantageous to save the information under the name of the customer. In time, when resistors require recalibration, the setup file can be loaded with all the pertinent data.**

If the current setup was not saved, pressing the **Exit** key returns the user to the Main Menu Screen.

3.4 Calibration Menu Screen



Stage	Correction Factor (x10E-6)	Standard Deviation (95%) (x10E-6)	Change from last Calibration (x10E-6)
1	-0.010	0.007	0.007
2	0.002	0.007	0.010
3	-0.014	0.007	-0.014
4	-0.023	0.007	0.000
5	-0.013	0.006	-0.004
6	-0.010	0.007	0.004
7	-0.011	0.008	0.010
8	0.065	0.006	-0.002
9	-0.475	0.005	0.008
10	-0.858	0.006	-0.011
11	2.123	0.005	0.017
12	0.708	0.006	0.023
13	-1.491	0.005	-0.035

Figure 8 ... Calibration Menu Screen

The **Calibration Menu Screen** allows the user to calibrate the Model 6000A. Figure 8 displays the menu screen along with typical calibration data.

3.4.1 Calibration Information

Calibration information is displayed in the data boxes in the upper portion of the Calibration Menu Screen. This information includes the **"6000A Serial Number"**, **"Calibration Date"**, **"Calibration Time"**, and **"Calibration Personnel"**. The serial number of the Model 6000A is obtained from the Setup Menu Screen, so it must be modified there. However, before a calibration is performed, modify the Calibration Personnel so that the user's name is printed in the calibration report.

The **Source Voltage** is obtained from the Setup Menu Screen and updated at the beginning of the calibration procedure. If a Rotronic AM3 device is connected to the system, the **Temperature** and **Humidity** of the lab environment is displayed in the appropriate data box. Likewise, if a Mensor 15000 Barometer is connected, the **Pressure** is displayed in its data box.

A Calibration Table is displayed in the lower portion of the Calibration Menu Screen. This table displays the *Correction Factors* and *Standard Deviation* of the thirteen individual stages in the Model 6000A. The last column in the table indicates the change in correction factors from the last calibration. If this change is greater than 0.1×10^{-6}, a warning message is displayed at the bottom of the screen and an asterisk is placed beside the value in the table.

> **NOTE: Before performing measurements for the first time, calibration on the Model 6000A should be performed twice to avoid obtaining the warning message. Ensure that the Model 6000A has reached equilibrium at room temperature, and if a large difference from the last calibration still occurs, consult the factory.**

3.4.2 Calibration Menu Keys

- **Calibrate:** This menu key calibrates the Model 6000A. The correction factors for each individual stage are measured and displayed in the Calibration Table.

- **Abort Cal:** This menu key aborts the calibration procedure. If the calibration procedure was not completed, the correction factors for each individual stage will not be updated.

- **Display Last Cal:** This menu key loads and displays the last calibration data from the file *"CAL_FACT.DAT"*.

- **Save Cal:** This menu key saves a calibration report to the file *"CAL_HIST.DAT"*. This file is not overwritten every time a calibration is saved; each calibration is appended to the file to create a calibration history. To access this calibration data file, select "Calibration History" from the Output Data Menu Screen (refer to Section 4.3).
- **Print Cal:** This menu key prints a calibration report if a printer is connected to the computer.

- **Exit:** This menu key exits the Calibration Menu Screen and returns the user to the Main Menu Screen.

3.5 Resistor Menu Screen

3.5.1 Resistor Information

Figure 9 displays an example of the **Resistor Menu Screen**.

When creating a resistor file, enter the required information into the data boxes at the top of the screen. This information can then be copied to the Resistor Table below, which displays all resistors in the resistor file.

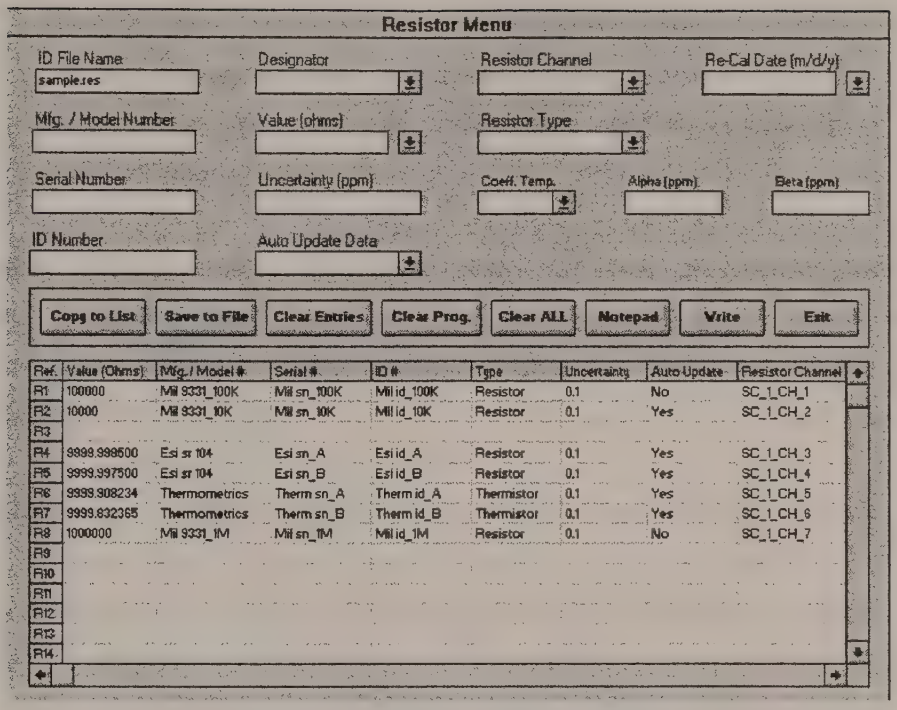

Resistor Menu
ID File Name
sample.res
Designator
Resistor Channel
Re-Cal Date (m/d/y)
Mfg. / Model Number
Value (ohms)
Resistor Type
Serial Number
Uncertainty (ppm)
Coeff. Temp.
Alpha (ppm)
Beta (ppm)
ID Number
Auto Update Data
Copy to List
Save to File
Clear Entries
Clear Prog.
Clear ALL
Notepad
Write
Exit
Ref. | Value (Ohms) | Mfg. / Model # | Serial # | ID # | Type | Uncertainty | Auto Update | Resistor Channel
R1 | 100000 | Mil 9331_100K | Mil sn_100K | Mil id_100K | Resistor | 0.1 | No | SC_1_CH_1
R2 | 10000 | Mil 9331_10K | Mil sn_10K | Mil id_10K | Resistor | 0.1 | Yes | SC_1_CH_2
R3
R4 | 9999.998500 | Esi sr 104 | Esi sn_A | Esi id_A | Resistor | 0.1 | Yes | SC_1_CH_3
R5 | 9999.997500 | Esi sr 104 | Esi sn_B | Esi id_B | Resistor | 0.1 | Yes | SC_1_CH_4
R6 | 9999.908234 | Thermometrics | Therm sn_A | Therm id_A | Thermistor | 0.1 | Yes | SC_1_CH_5
R7 | 9999.832365 | Thermometrics | Therm sn_B | Therm id_B | Thermistor | 0.1 | Yes | SC_1_CH_6
R8 | 1000000 | Mil 9331_1M | Mil sn_1M | Mil id_1M | Resistor | 0.1 | No | SC_1_CH_7
R9
R10
R11
R12
R13
R14

Figure 9 ... Resistor Menu Screen

A brief description of the individual data boxes follows:

- **ID File Name:** This name represents the resistor file name previously loaded.
- **Mfg. / Model Number:** Enter the manufacturer's name and model number.
- **Serial Number:** Enter the serial number of the resistor.
- **ID Number:** Enter the identification number for the resistor.
- **Designator:** Enter a reference number in which the resistor should be located in the Resistor Table.

NOTE: A maximum of 40 resistors may be entered in the Resistor Table. This number reflects the maximum number of resistor channels when two scanners are connected to the system. To enter more than 40 resistors, another resistor file must be created.

- **Value:** Enter the absolute value of the resistor (in ohms) using the drop-down menu selections or by typing in a value. The range is displayed in the drop-down menu selections. When entering a thermistor, the *"Value"* heading is changed to *"R_o @ 25 C"*.

- **Uncertainty:** Enter the uncertainty of the resistor from its calibration report.

- **Auto Update Data:** Should the resistor data be automatically updated? If *"Yes"* is selected, then the value and uncertainty for that resistor will be updated in the Resistor Table after the measurement sequence. If *"No"* is selected, then the value and uncertainty will remain the same.

  NOTE: If resistor values were updated, remember to save the resistor file to preserve the updated resistor information.

- **Resistor Channel:** Enter the channel to which the resistor is connected to. This drop-down menu will display selections depending on how many scanners are connected to the system. For no scanners, the drop-down menu selections (*"CH_1"* to *"CH_4"*) indicate channels R_1 to R_4 at the rear of the Model 6000A. If scanners are connected, the drop-down menu selections indicate the number of the scanner, as well as the channel.

  ie. *"SC_1_CH_5"* indicates Channel 5 of Scanner #1

- **Resistor Type:** Enter the resistive type, whether it is an actual resistor or a thermistor.

- **Re-Cal Date:** Enter the date in which the resistor should be re-calibrated. This date is printed in the Report of Calibration (refer to Section 4.3).

- **Coeff. Temp.:** Enter the coefficient temperature (20 °C, 23 °C, or 25 °C) used for the resistor. This option is only selected for ESI resistors or for resistors with an *Alpha* and *Beta* coefficient. If *Alpha* and *Beta* coefficients are not known, do not enter a coefficient temperature. When entering a thermistor, this drop-down menu is hidden.

- **Alpha:** Enter the *Alpha* coefficient (in ppm) for the resistor if available. This coefficient is obtained from the calibration report and is used to calculate the temperature corrected resistance value. If an *Alpha* coefficient is entered, a coefficient temperature must also be entered for the resistor to ensure that the resistance value is corrected to the proper temperature. When entering a thermistor, this data box is hidden.

- **Beta:** Enter the *Beta* coefficient (in ppm) for the resistor if available. This coefficient is obtained from the calibration report and is used to calculate the temperature corrected resistance value. If a *Beta* coefficient is entered, a coefficient temperature must also be entered for the resistor to ensure that the resistance value is corrected to the proper temperature. When entering a thermistor, this data box is hidden.

- **a constant:** Enter the "a" constant of the thermistor obtained from the calibration report. When entering a resistor, this data box is hidden.

- **b constant:** Enter the "b" constant of the thermistor obtained from the calibration report. When entering a resistor, this data box is hidden.

- **c constant:** Enter the "c" constant of the thermistor obtained from the calibration report. When entering a resistor, this data box is hidden.

The "a", "b", and "c" constants are used to convert the thermistor resistance to temperature using the Steinhart-Hart equation. The temperature obtained is then used to correct the resistance value of the ESI resistor.

To modify a resistor already displayed in the Resistor Table, use the mouse to click on the row of the Resistor Table in which the resistor to be modified is referenced by. This copies all the resistor information to the data boxes above. Here, parts of the resistor information may be modified and then updated in the Resistor Table. Once changes are made, be sure to save them to the existing resistor file (refer to Section 3.5.2).

3.5.2 Resistor Menu Keys

The following gives a brief description of the menu keys shown in the Resistor Menu Screen (refer to Figure 9):

- **Copy to List:** This key copies all resistor information from the data boxes above to the Resistor Table at the bottom of the screen.

- **Save to File:** This key saves all information in the Resistor Table to a resistor file so that it can be loaded at any time.

- **Clear Entries:** This key clears all entries in the data boxes above except for the *"ID File Name"*.
- **Clear Prog.:** This key clears all information for a resistor, referenced by the name shown in the *"Designator"* box, from the Resistor Table. If nothing is displayed in the *"Designator"* box, then nothing is cleared from the Resistor Table. To delete a resistor permanently, remember to select *"Save to File"* to update the resistor file.

- **Clear ALL:** This key clears all resistors from the Resistor Table to allow the user to create a new resistor file. The *"ID File Name"* data box now

displays *"New.res"*, however, the user is able to rename the resistor file by selecting the *"Save to File"* menu key.

- **Notepad:** This key copies all information in the Resistor Table to Windows *"Notepad"* to allow the user to print the information or import it into a desired spreadsheet application.

- **Write:** This key works the same as *"Notepad"*, but instead copies the information in the Resistor Table to Windows *"Write"*.

- **Exit** - This key exits the Resistor Menu Screen and returns the user back to the Main Menu Screen.

> **NOTE: Many different resistor files may be created. It may be advantageous to save the information under the name of the customer. In time, when resistors require recalibration, the resistor file can be loaded with all the pertinent data. This will also allow the user to track the history on the resistors.**

3.6 Program Menu Screen

The **Program Menu Screen** is used to create, edit, or select a program for automated measurements. A measurement program of two resistors may be created or edited from this menu screen. To perform automated measurements on a number of resistors, a combined program consisting of several individual measurement programs may also be created.

The choices indicated from the Program Menu Screen are as follows:

- *Select an active program*
- *Create / Edit a measurement program*
- *Create a combined program from individual measurement programs*

The Program Menu Screen is divided into three sections: the top left portion of the screen displays the Resistor Table from the Resistor Menu Screen; the bottom portion displays a Program Table; the top right portion displays program information and menu keys depending on what action is taking place. All entries are made using the mouse.

3.6.1 Selecting a Program

When the Program Menu Screen is initially displayed, **"Select active program"** is highlighted with program **P1** displayed in the corresponding data box (refer to Figure 10). To select a different program to run, use the mouse to click on the row of the desired program in the Program Table. This program will be displayed in the data box beside **"Select active program"**.

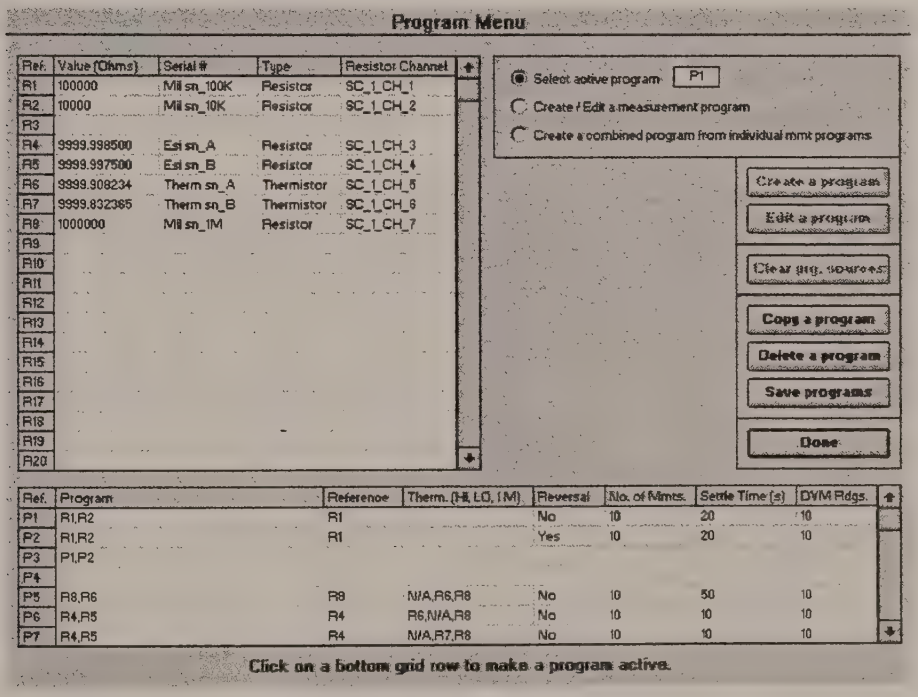

Program Menu
Ref. Value (Ohms) Serial # Type Resistor Channel
R1 100000 Mil sn_100K Resistor SC_1_CH_1
R2 10000 Mil sn_10K Resistor SC_1_CH_2
R3
R4 9999.998500 Esi sn_A Resistor SC_1_CH_3
R5 9999.997500 Esi sn_B Resistor SC_1_CH_4
R6 9999.908234 Therm sn_A Thermistor SC_1_CH_5
R7 9999.832365 Therm sn_B Thermistor SC_1_CH_6
R8 1000000 Mil sn_1M Resistor SC_1_CH_7
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
Select active program P1
Create / Edit a measurement program
Create a combined program from individual mmt programs
Create a program
Edit a program
Clear prg. sources
Copy a program
Delete a program
Save programs
Done
Ref. Program Reference Therm. (HI, LO, IM) Reversal No. of Mmts. Settle Time (s) DVM Rdgs.
P1 R1,R2 R1 No 10 20 10
P2 R1,R2 R1 Yes 10 20 10
P3 P1,P2
P4
P5 R8,R6 R8 N/A,R6,R8 No 10 50 10
P6 R4,R5 R4 R6,N/A,R8 No 10 10 10
P7 R4,R5 R4 N/A,R7,R8 No 10 10 10
Click on a bottom grid row to make a program active.

Figure 10 ... Selecting a Program

The functions of the menu keys displayed are as follows:

- **Copy a program:** This menu key copies an existing program from one program reference location in the Program Table to another location. This may be useful for moving programs in the Program Table.

- **Delete program:** This menu key deletes all information for a program from the Program Table. To delete a program permanently, remember to select *"Save programs"* to update the program file.

- **Save programs:** This menu key saves all information in the Program Table to a program file so that it may be loaded at any time.

- **Done:** This menu key returns the user to the Main Menu Screen once a program has been selected, created, or modified.

3.6.2 Creating / Editing a Measurement Program

From the Program Menu Screen, select **"Create / Edit a measurement program"** using the mouse. Once selected, more program data boxes appear. Figure 11 displays the menu screen for creating or editing a measurement program.

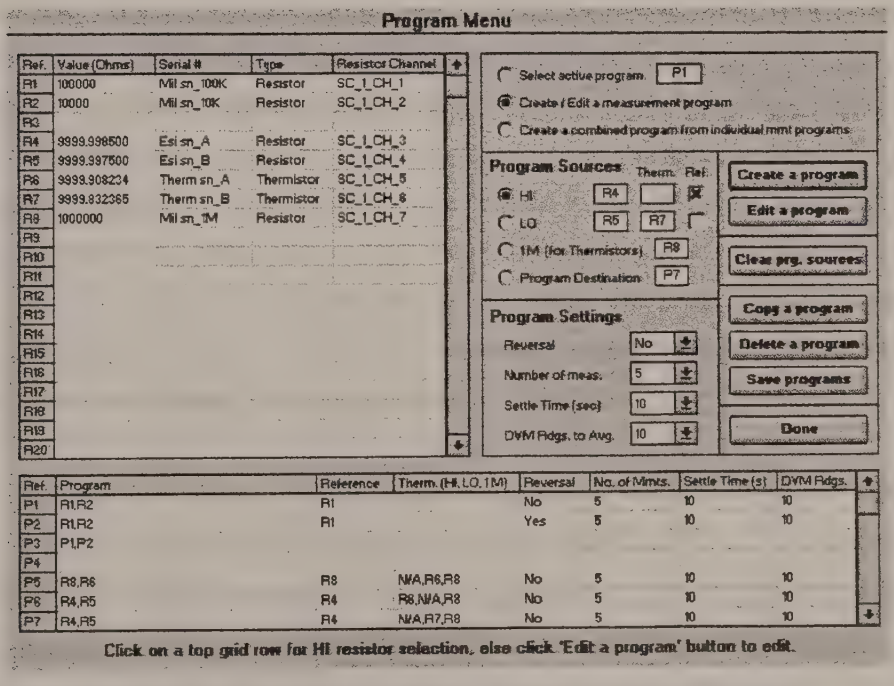

Program Menu
Ref. | Value (Ohms) | Serial # | Type | Resistor Channel
R1 | 100000 | Mil sn_100K | Resistor | SC_1_CH_1
R2 | 10000 | Mil sn_10K | Resistor | SC_1_CH_2
R4 | 9999.998500 | Esi sn_A | Resistor | SC_1_CH_3
R5 | 9999.997500 | Esi sn_B | Resistor | SC_1_CH_4
R6 | 9999.908234 | Therm sn_A | Thermistor | SC_1_CH_5
R7 | 9999.832365 | Therm sn_B | Thermistor | SC_1_CH_6
R8 | 1000000 | Mil sn_1M | Resistor | SC_1_CH_7
Select active program
Create / Edit a measurement program
Create a combined program from individual mmt programs
Program Sources
Therm.
Ref.
HI
LO
1M (for Thermistors)
Program Destination
Program Settings
Reversal
Number of meas.
Settle Time (sec)
DVM Rdgs. to Avg.
Create a program
Edit a program
Clear prg. sources
Copy a program
Delete a program
Save programs
Done
Ref. | Program | Reference | Therm. (HI, LO, 1M) | Reversal | No. of Mmts. | Settle Time (s) | DVM Rdgs.
P1 | R1,R2 | R1 | | No | 5 | 10 | 10
P2 | R1,R2 | R1 | | Yes | 5 | 10 | 10
P3 | P1,P2
P4
P5 | R8,R6 | R8 | N/A,R6,R8 | No | 5 | 10 | 10
P6 | R4,R5 | R4 | R8,N/A,R8 | No | 5 | 10 | 10
P7 | R4,R5 | R4 | N/A,R7,R8 | No | 5 | 10 | 10
Click on a top grid row for HI resistor selection, else click 'Edit a program' button to edit.

Figure 11 ... Creating / Editing a Measurement Program

Program Sources

To create a measurement program for two resistors (without thermistors), first select the **HI** value by using the mouse to click on the desired resistor in the Resistor Table. The resistor reference number selected will be displayed in the data box beside the **HI** option, and the **LO** option will be highlighted. Next, repeat this step to select the **LO** resistor. Once both resistors are selected, select the **Program Destination** by using the mouse to click on an empty row in the Program Table. The program reference will be copied to the data box.

In order to perform a direct reading in terms of absolute, it is necessary to select a known resistor value as the reference resistor. The 6000A Software allows the user to create a program with the reference resistor in either the **HI** or **LO** position. To do so, select the **HI** or **LO** resistor as the reference by checking off the appropriate reference checkbox **("Ref.")**.

The 6000A Software also allows the user to create programs involving ESI resistors and thermistors to obtain temperature corrected resistance values for an unknown resistor. To create a measurement program for two resistors involving thermistors, the same procedure applies except the thermistors also have to be selected. If the **HI** resistor selected contains a thermistor attached to it, click on the **HI** option once again and select its thermistor from the Resistor Table. Likewise, if the **LO** resistor contains a thermistor, the **LO** resistor, as well as its thermistor, must be selected from the Resistor Table. The thermistor reference numbers will be displayed under the data boxes **("Therm.")** beside the **HI** and **LO** options.

If a thermistor is selected, a 1 MΩ resistor must also be selected for the program since the 10 KΩ thermistor requires an operating current of 10 μA. By selecting a 1 MΩ resistor as the reference for the 10 KΩ thermistor, the 100:1 ratio causes the operating current through the thermistor to be reduced from 1 mA to 10 μA. Once all resistors and associated thermistors are selected, select the **Program Destination** in the Program Table.

NOTE: When entering data for *"Program Sources"*, the instruction displayed at the bottom of the screen should be followed to guide the user in creating a measurement program. This is especially useful when creating programs using thermistors, since this instruction will inform the user whether a resistor or thermistor should be selected next.

Program Settings

- **Reversal:** A reversal (or *"Symmetrically Inverted Measurement"*) may be performed to verify the linearity and calibration corrections. Enter *"Yes"* or *"No"* using the drop-down menu. The reference resistor remains as defined during a reversal measurement.

  NOTE: A reversal cannot be selected for a thermistor measurement.

- **Number of meas.:** Enter in the number of measurements to be made (between 1 and 250) using the drop-down menu.

- **Settle Time:** Enter the settling time in seconds (between 4 and 1000) using the drop-down menu. The following table displays the recommended settling times for different values of resistors.

Larger Resistor	Settle Time (sec.)
10 KΩ	10
100 KΩ	20
1 MΩ	50
10 MΩ	70
100 MΩ	140
1 GΩ	270

The settling times displayed in the above table are typical values. The settling times selected will depend on the input offset current of the DVM

used. The larger the offset current, the more time is required before the DVM should begin to take readings, and thus, the larger the settling time should be.

To verify that the settling time used is sufficient, observe the standard deviations at the individual stages (P1, P2 for HI & LO) of the ratio measurement from a measurement printout. At the lower end, if the standard deviations are greater than 0.1 ppm for 10 KΩ resistors, increase the settling time to avoid taking DVM readings while the DVM is still charging. Likewise, if the standard deviations are greater than 0.5 ppm for 1 GΩ resistors, again, increase the settling time.

- **DVM Rdgs. to Avg.:** Enter the number of readings the DVM should average (between 3 and 100) using the drop-down menu. The recommended number of DVM readings to average for the listed DVMs is 10. The larger the number of readings, the more accurate the average is, thus, increasing the accuracy of the measurements.

Some of the menu keys displayed are described in Section 3.6.1. The functions of the additional menu keys are as follows:

- **Create a program:** This menu key creates an individual or combined program by copying the information in the data boxes to the Program Table.

  NOTE: A maximum of 60 programs may be entered in the Program Table. To create more than 60 programs, another program file must be created.

- **Edit a program:** This menu key edits an existing measurement program. The software will prompt the user to select the program to edit and all information related to that program will be copied to the data boxes under *"Program sources"* and *"Program settings"*. Modify the data boxes as required and then select *"Create a program"* to copy the modified

information to the Program Table. Remember to select *"Save programs"* to store the modified programs to a file.

- **Clear prg. sources:** This menu key clears all information in the data boxes under *"Program Sources"* so that a new program may be created.

3.6.3 Creating a Combined Program

Combined programs are necessary to perform measurements on various resistors or for scaling resistors from 1 KΩ to 1 GΩ. From the Program Menu Screen, select **"Create a combined program from individual measurement programs"** using the mouse. Once selected, more program data boxes appear. Figure 12 displays the menu screen for creating a combined program for performing automated measurements on a number of resistors.

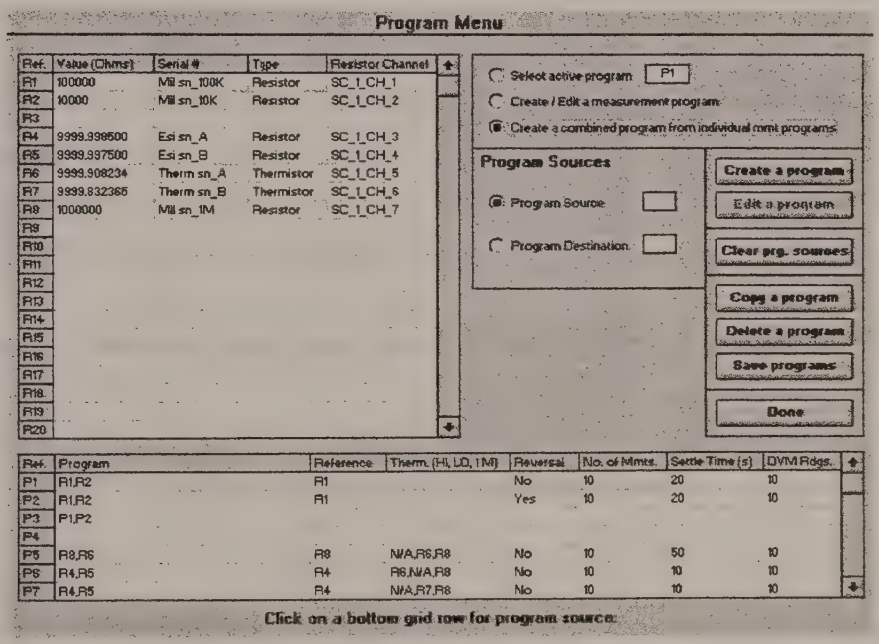

Program Menu
Ref. | Value (Ohms) | Serial # | Type | Resistor Channel
R1 | 100000 | Mil sn_100K | Resistor | SC_1_CH_1
R2 | 10000 | Mil sn_10K | Resistor | SC_1_CH_2
R4 | 9999.998500 | Esi sn_A | Resistor | SC_1_CH_3
R5 | 9999.997500 | Esi sn_B | Resistor | SC_1_CH_4
R6 | 9999.908234 | Therm sn_A | Thermistor | SC_1_CH_5
R7 | 9999.832365 | Therm sn_B | Thermistor | SC_1_CH_6
R8 | 1000000 | Mil sn_1M | Resistor | SC_1_CH_7
Select active program
P1
Create / Edit a measurement program
Create a combined program from individual mmt programs
Program Sources
Program Source
Program Destination
Create a program
Edit a program
Clear prg. sources
Copy a program
Delete a program
Save programs
Done
Ref. | Program | Reference | Therm. (HI, LO, 1M) | Reversal | No. of Mmts. | Settle Time (s) | DVM Rdgs.
P1 | R1,R2 | R1 | | No | 10 | 20 | 10
P2 | R1,R2 | R1 | | Yes | 10 | 20 | 10
P3 | P1,P2
P5 | R8,R6 | R8 | N/A,R6,R8 | No | 10 | 50 | 10
P6 | R4,R5 | R4 | R6,N/A,R8 | No | 10 | 10 | 10
P7 | R4,R5 | R4 | N/A,R7,R8 | No | 10 | 10 | 10
Click on a bottom grid row for program source.

Figure 12 ... Creating a Combined Program

To create a combined program, it is necessary to copy individual programs into one program. To do so, follow these simple steps:

(a) With **Program Source** highlighted, select (using the mouse) the first individual program to combine from the Program Table. The program reference will be displayed in the **Program Source** data box.

(b) **Program Destination** is now highlighted. Select the program reference from the Program Table in which the combined program should be located. This will be displayed in the **Program Destination** data box.

(c) Select **"Create a Program"** from the menu keys. The first program will be displayed in the Program Table at the combined program location (ie. the program reference selected in step 'b').

(d) The **Program Source** should be highlighted once again. Select the next program to combine from the Program Table. There is no need to select **Program Destination** again, so select **"Create a program"** to enter the next individual program to be run.

(e) Repeat the procedure for the remaining programs to combine until all programs have been entered. The result is a combined program consisting of a number of individual programs. The maximum number of programs that may be combined is 20.

(f) Select **"Save programs"** to save the Program Table to a program file for future use.

NOTE: Combined programs cannot be combined.

4.1 Loading / Saving Files

The **Files Menu Screen** (refer to Figure 13) allows the user to load previously saved files, as well as save current files. This menu option can be selected from the menu keys at the top of the Main Menu Screen or through the Setup, Resistor, and Program Menu options.

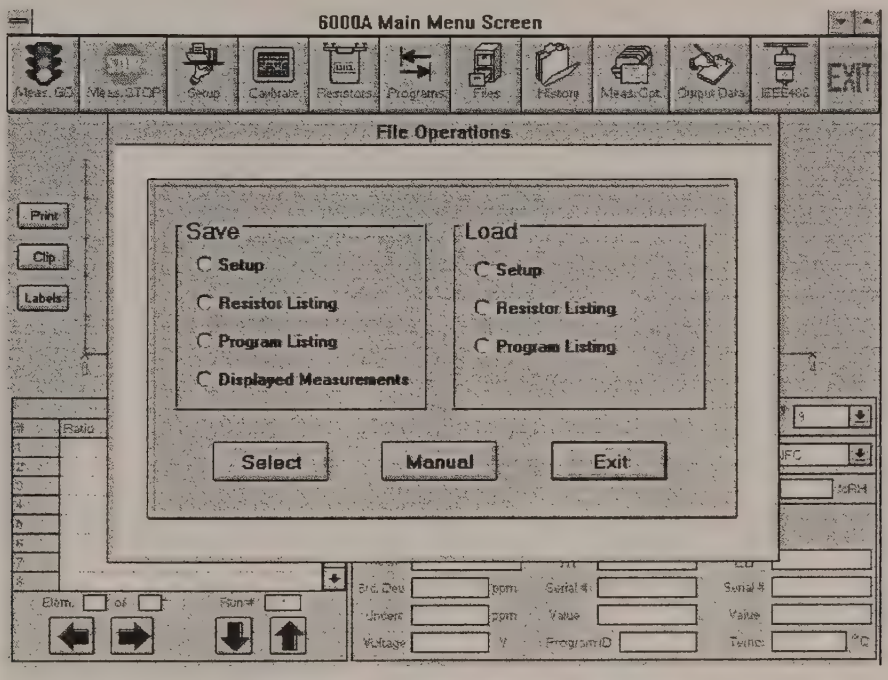


Figure 13 ... Files Menu Screen

To save or load files, highlight the type of file (*Setup*, *Resistor Listing*, or *Program Listing*) using the mouse and choose **Select**. The user is then prompted to select the desired drive / directory for the location of the file, as well as the file name. The file extension is already provided. This menu screen also allows the user to save the displayed measurements to a file after a measurement run.

The **Manual** button displays the Model 6000A Operating Manual under Windows *"Write"* to be used as a reference. This manual, however, contains only text (no figures are included).

4.2 Measurement Options

The **Measurement Options Screen** (refer to Figure 14) provides the user with many options in performing a measurement run.

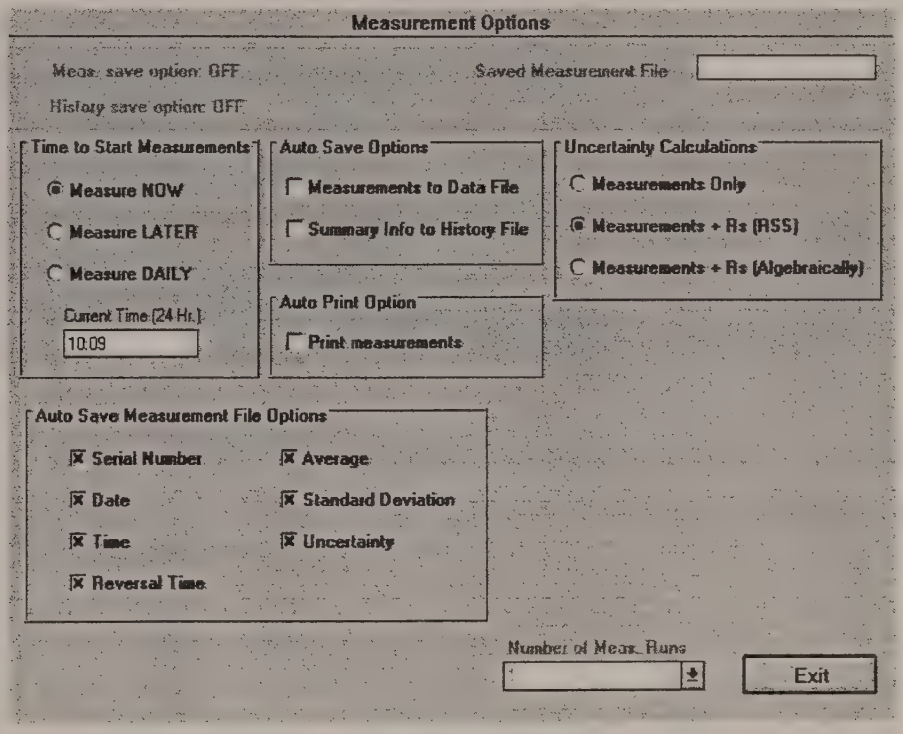


Figure 14 ... Measurement Options Screen

The measurement options include:

- performing measurements at a later time
- saving measurements to a data file
- saving the measurement summary to a history file
- sending measurements to a printer
- selecting the method for uncertainty calculations
- selecting the number of measurement runs between 1 and 3
- selecting the delay between measurement runs up to 480 minutes

4.2.1 Auto Save Options

The **Auto Save Options** allow the user to save measurements to a data file or save the measurement summary to a history file for future reference. To do so, select the appropriate choice under *"Auto Save Options"*. The top of the screen will display whether Measurement / History Save Options are **ON** or **OFF**. If the Measurement Save Option is selected the user is prompted for a filename (with extension "mea") to store the measured results. When saving summary information to a history file, the history file name will automatically be named according to serial number of the source being measured. This serial number is obtained directly from the Source Table in the Source Menu screen, with spaces being replaced by underscore characters ("_"). Serial numbers that contain more than 8 characters in length are cut off to the left characters.

> NOTE: **For large serial numbers that differ in the first few characters, enter only the first 8 characters of the serial number or the changing characters in the Source Table.**

When saving measurements to a data file, additional information may be added to the file depending on the user's requirements. Under *"Auto Save Measurement File Options"*, select the information required, which includes: 6000A serial number, measurement date, measurement time, reversal time, measurement average, standard deviation, and uncertainty.

4.2.2 Measurement Time

The *"Start Measurement Options"* section allows the user to begin measurements at any time within a 24-hour time period. To perform a measurement run immediately, select **Measure NOW**. Selecting **Measure LATER** displays a drop-down menu showing a 24-hour time clock with 10 minute and 15 minute intervals. These selections reflect the start time of an actual clock rather than the start time period.

ie. selecting *"00:20"* means measurements will begin at 12:20 AM, not 20 minutes from the current time

Selecting **Measure DAILY** will perform the same measurement run every day at the specified time until measurements are aborted.

4.3 Output Data

The **Output Data Screen** (refer to Figure 15) is displayed when the *"Output Data"* menu key is selected from the Main Menu Screen. This screen is useful for outputting important data to either Windows *"Notepad"* or *"Write"*, as well as loading previously saved data files.

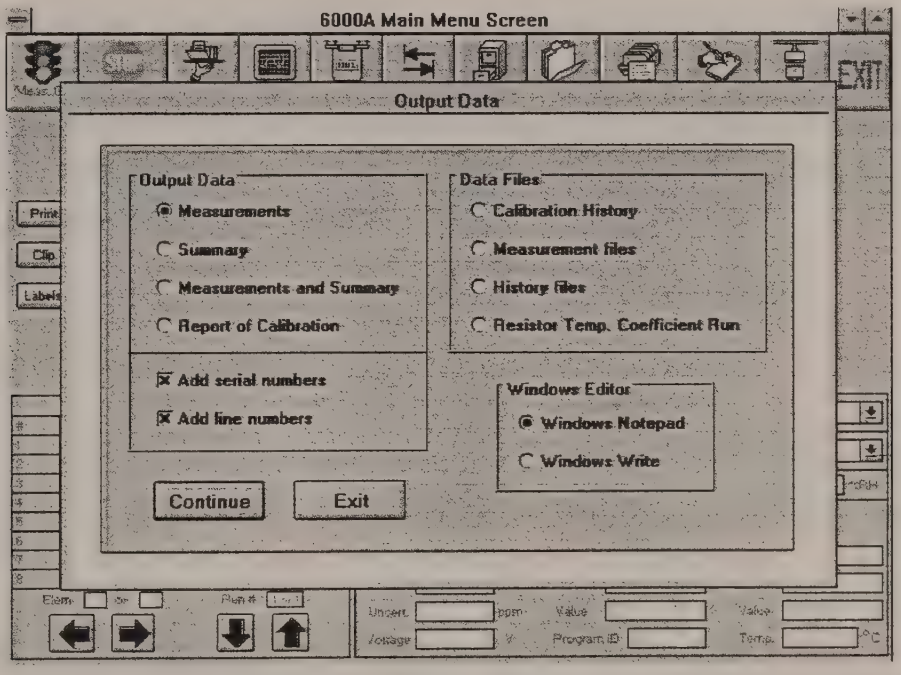


Figure 15 ... Output Data Screen

Either Windows *"Notepad"* or *"Write"* may be selected depending on the user's preference. To output data after a measurement run, select the appropriate choice under *"Output Data"* (**Measurements**, **Summary**, **Measurements and Summary**) and the information will be transferred to the selected text editor under the file name **"MI.TXT"**. The user may also add the serial numbers for the **HI** & **LO** resistors used in the measurement run, as well as the line numbers of the measurements. If a resistor measurement was just performed, a **Report of Calibration** may be obtained containing all the pertinent information for the calibrated resistor, as well as the reference resistor. This data file is also named **"MI.TXT"**, so be sure to rename it accordingly.

Previously saved data files may be loaded from the Output Data Screen. To observe a history of the Model 6000A calibration data, select **Calibration History** under *"Data Files"*. **Measurement files, History files,** and **Resistor Temperature Coefficient** data files may also be loaded from the Output Data Screen. These files should not have to be modified and should be loaded primarily for observation.

4.4 History Of Measurements

Selecting the **History** menu key from the Main Menu Screen allows the user to save the displayed summary data to a history file or load history data from a previously saved file. The save option may also be performed from the Measurement Options Screen.

> **NOTE: When performing more than one measurement run, the average of the runs will be saved to history as opposed to each run.**

As an example, load the history file **"SAMPLE.HIS"** (refer to Figure 16). The graph plots the resistance of a 10 KΩ resistor plotted relative to the mean for 10 iterations. This mean value, as well as the minimum and maximum values, is displayed directly below the graph. To observe the standard deviation and/or best fit curve on the history of the resistor, select the appropriate choice using the mouse.

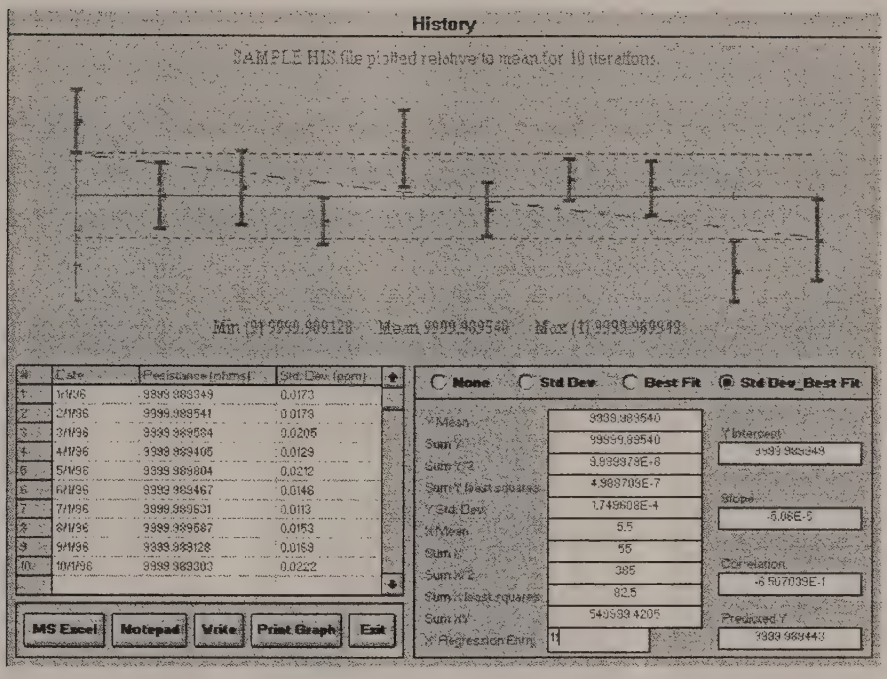


Figure 16 ... History Screen

The History Table in the lower left portion of the screen displays the date, mean resistance value, and standard deviation for the individual measurement summaries. This information may be exported to Microsoft Excel by selecting the **MS Excel** menu key below the History Table. To copy the data to a Windows editor, select the **Notepad** or **Write** menu key. If a printer is connected, selecting the **Print Graph** menu key prints the history graph.

The 6000A Software allows the user to perform linear regression analysis on the history of measurements to predict the resistor value in the future. This is done by using the "least squares" method to calculate a straight line that best fits the history data. To perform regression analysis on the next (or 11th) point, enter *"11"* into the **X Regression Entry** data box and press **Enter**. The **Y Intercept**, **Slope**, **Correlation**, and **Predicted Y** value for this point will be calculated and displayed.

4.5 IEEE488 Options

The **IEEE488 Menu Screen** (refer to Figure 17) is displayed when the *"IEEE488"* menu key is selected from the Main Menu Screen. This screen is useful in checking for problems with the IEEE488 Driver, which will be described further in the following sections.

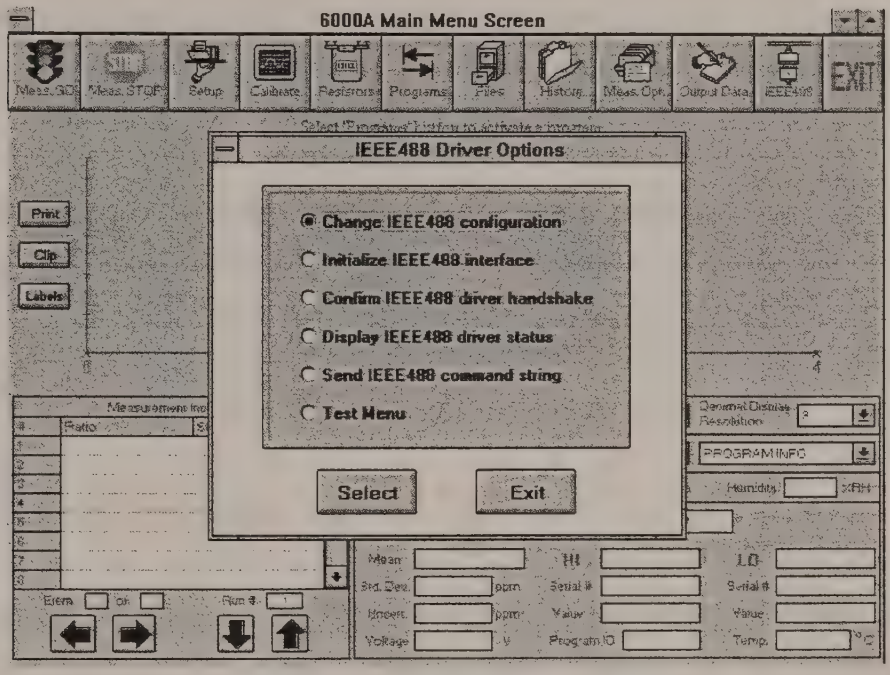
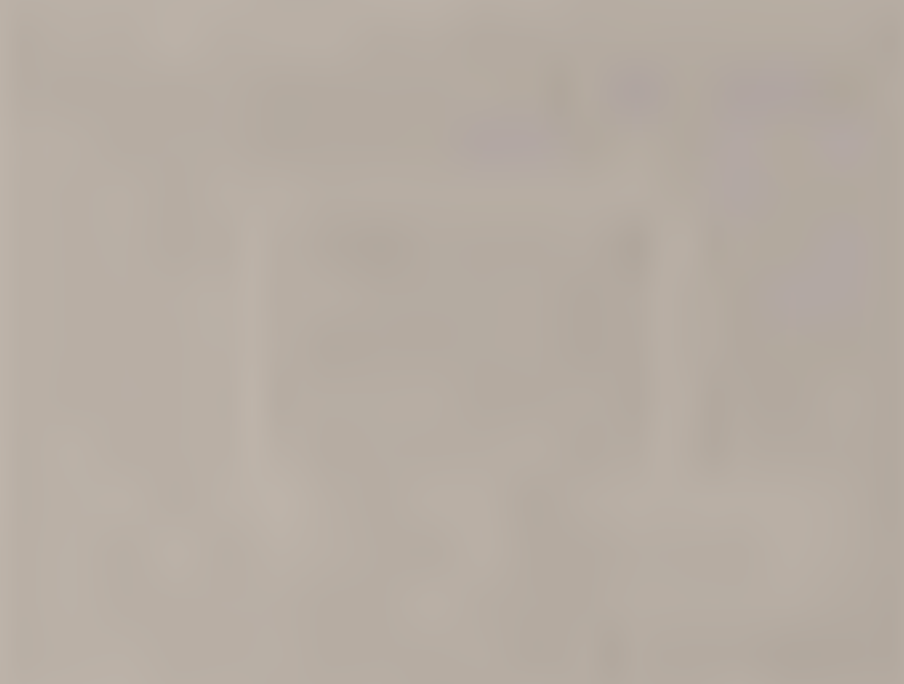


Figure 17 ... IEEE488 Menu Screen

4.5.1 IEEE488 Driver Options

The IEEE488 Driver options that may be selected from the IEEE488 Menu Screen include:

- **Change IEEE488 Configuration:** This option allows the user to modify the IEEE488 Configuration for the instruments used in the system in the same way as the *"Configure"* key in the Opening Menu Screen (refer to Section 3.1.2 and Figure 4 of this manual).



- **Confirm IEEE488 Driver handshake:** This option confirms whether or not handshaking occurs through the IEEE488 interface. If the driver software is able to both talk and listen across the IEEE488 interface, then handshaking will be confirmed, otherwise an error message will be displayed.

- **Initialize IEEE488 Interface:** This option initializes the IEEE488 interface so that the 6000A Software can communicate with the various units in the system. This is done immediately upon loading the 6000A Software and need not be initialized again unless problems occur with the IEEE488 interface.

- **Display IEEE488 Driver status:** This option displays the status of the IEEE488 driver including the primary and secondary addresses, the serial request number (SRQ), and various transfer bytes which are important for proper communication. Refer to the IEEE488 Driver Manual for more information on the driver status.

4.5.2 Send Command String

The **Send IEEE488 command string** option from the IEEE488 Menu Screen allows the user to test the hardware individually over the IEEE488 interface bus (refer to Figure 18).

To test a specific instrument, select **Create** to enter the device name and its address. To send a command to the unit, type in the character or command string under **Output Data / Commands** and select **Send**. The instrument should respond assuming a correct command is sent. For proper commands, refer to the instrument's Operating Manual.

For example, to test if the Model 6000A is responding over the IEEE488 interface bus, create an instrument with device name **"HI_BRDG"** and address **"14"**. Now send an **"*"** to the Model 6000A to put the unit into remote mode and verify that the remote LED on the Model 6000A turns on.

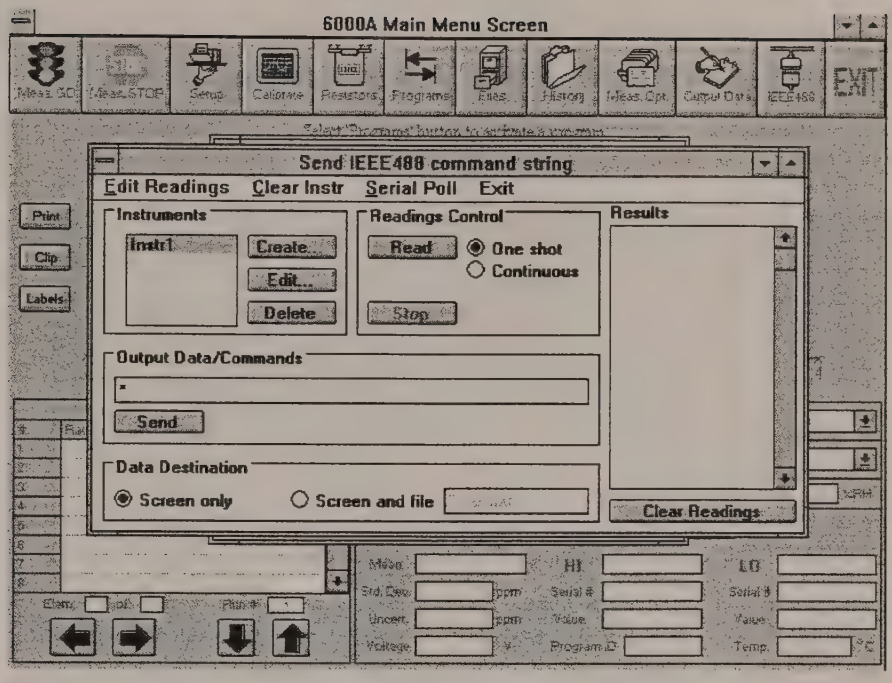


Figure 18 ... Sending an IEEE488 Command String

Besides sending commands, this menu is also capable of reading information sent from an instrument over the IEEE488 interface bus. Serial Poll Requests may also be observed during communication between the 6000A Software and the instrument.

4.5.3 Test Menu

The **Test Menu** allows the user access to the internal controls of the Model 6000A and serves as a testing tool to verify that the 6000A system is functional (refer to Figure 19).

To test the front panel LEDs of the Model 6000A, click on an **Upper Resistor** number and verify that the correct LED is illuminated on the Model 6000A. The same can be done for the **Lower Resistor**. To observe the voltage at the potential terminals of the resistors selected, select the desired potential of the desired resistor under **Measurement Status**. For example, if **Upper Resistor 1** and **Lower Resistor 2** are selected, selecting **R1P2** will display full-scale voltage on the

DVM provided all divider stages are reset. Setting a divider stage will subtract the set ratio from the potential terminal voltage. To display the DVM value, select **Read Value** under *"Read DVM"*.

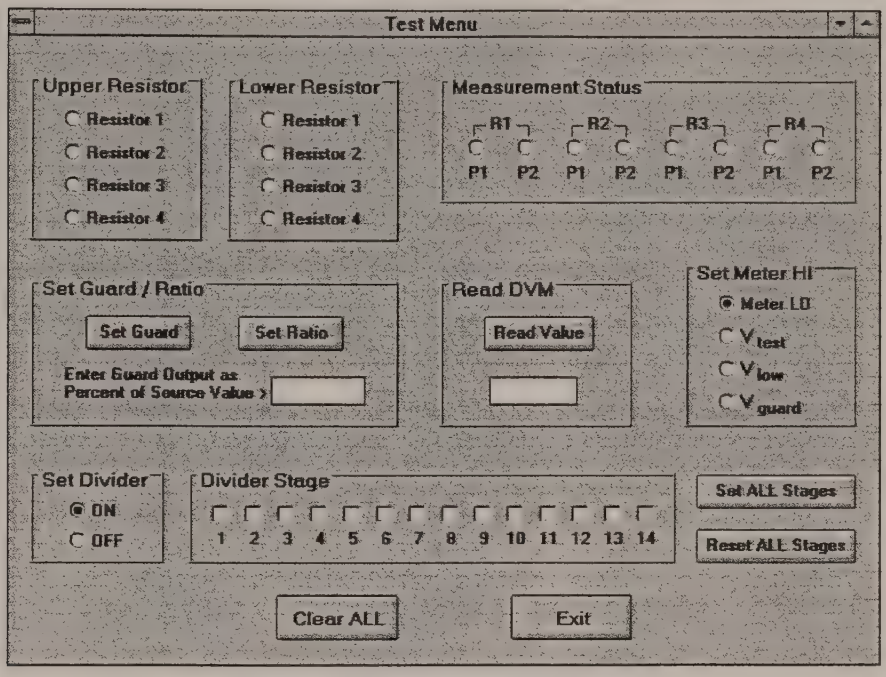


Figure 19 ... Test Menu Screen

The different divider stages of the Model 6000A can be set or reset at any time in the Test Menu. To set or reset a specific divider stage, click on the desired checkbox. A divider stage is set if the checkbox is marked. To **Set ALL Stages** or **Reset ALL Stages**, click on the appropriate menu keys.

The Test Menu also allows the user to read the DVM directly to verify that the DVM is communicating with the 6000A Software over the IEEE interface. As previously noted, clicking on the **Read Value** key will display the DVM reading (in Volts). To verify that the DVM is able to read the full-scale source voltage (10 or 20 V), set **Divider Stage 1**, set **Meter HI** to V_{low}, and read the DVM value. A negative value will be displayed corresponding to the source voltage. This check is useful whenever the error *"Stored & Measured Values do not agree"* is obtained during calibration or measurements.

The ratio of the divider can also be set by selecting the **Set Ratio** key. To do so, enter a fractional ratio (between 0 and 1) and the actual ratio will be displayed. If the divider is **ON**, then some of the divider stages should be checked depending on the ratio entered. To observe the voltage obtained, **Set Divider ON** and set **Meter HI** to V_{low}. The voltage displayed by reading the DVM value should be the divider ratio entered times the full-scale source voltage.

To set the guard output voltage, **Set Divider ON** and set **Meter HI** to V_{guard}. Next, click on the **Set Guard** key and enter the guard output as a percentage of the source voltage (0 to 100%). The guard output voltage can be displayed by reading the DVM value.

> **NOTE: The V_{test} option under "Set Meter HI" is only used in testing calibration of the Model 6000A and, therefore, should not be used. If problems occur in calibration, please consult the factory.**

To clear selected resistors and the measurement status, click on the **Clear ALL** key at the bottom of the Test Menu Screen. All LEDs in the Test Menu and the front panel of the Model 6000A should turn off. This key also short-circuits the DVM by re-initializing **Meter HI** to **Meter LO**. The **Exit** key returns the user to the IEEE488 Menu Screen.

5 Performing a Measurement

There are four key steps to performing a measurement using the MIL 6000A Software:

1. Resistor Identification
2. Program Generation
3. Calibration
4. Resistor Measurement

Once the first three steps have been completed, an actual resistor measurement run can be performed. This is described further in the following sections.

5.1 Performing a Resistance Measurement

After selecting the desired Setup, Resistor, and Program files from the Opening Menu Screen, the user is ready to begin a measurement run. Assuming that the resistors have been entered in the Resistor Table and a measurement program has been created and selected (refer to Sections 3.5 and 3.6), the user is now ready to perform a resistance measurement.

To select any of the measurement options described in Section 4.2, select the **"Meas. Opt."** menu key in the Main Menu Screen. Once the desired options are chosen, select the **"Meas. GO"** menu key to begin measurements. The user will notice information being displayed in the blue caption bar at the very top of the Main Menu Screen. This *"information bar"* displays commands transmitted via the IEEE interface both to and from the various units in the 6000A system. The function of these commands may be determined through the instruments' operating manuals.

During the measurement run, measurement information will be displayed and plotted (refer to Figure 20). This is described further in the following sections. To abort at any time during a measurement run, select the **"Meas. STOP"** menu key at the top of the screen. The 6000A Software may take a few seconds to shut down completely.

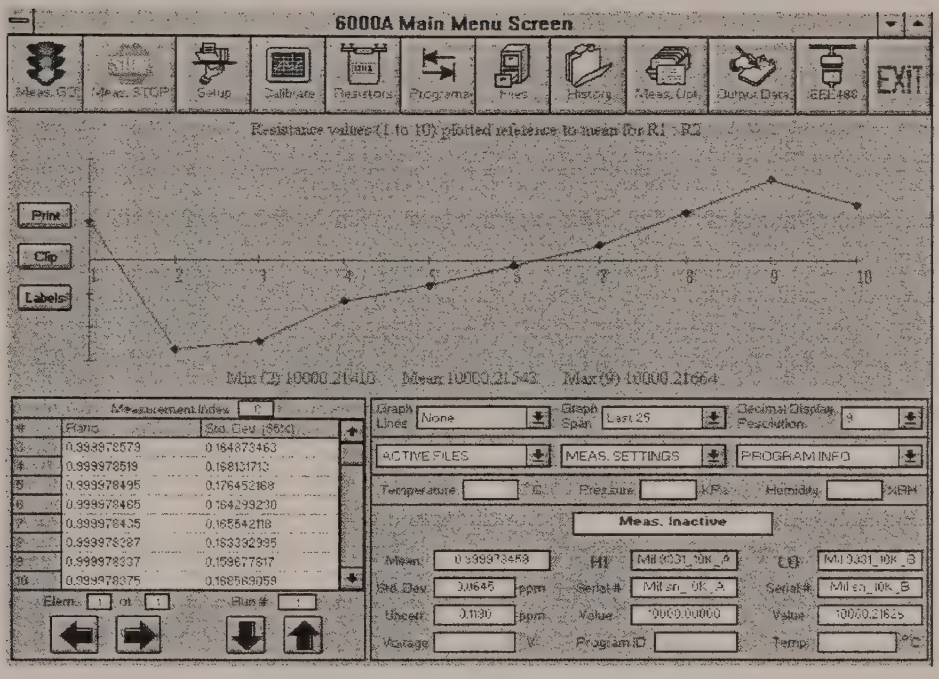


Figure 20 ... Resistance Measurement Run

5.1.1 Measurement Information

The lower right portion of the Main Menu Screen contains drop-down menus and information boxes that reveal important information about the measurement being performed. This information is continuously updated during the measurement sequence.

The drop-down menus can be accessed at any time, even during a measurement run. They include:

- **ACTIVE FILES:** The active files drop-down menu displays file names for the Setup, Resistor, and Program files previously loaded upon running the 6000A Software. If the save history option and save measurements to file option are enabled from the Measurement Options Screen, these file names are also displayed here.

- **MEAS. SETTINGS:** The measurement settings depend on the program selected and includes: the reference resistor, the thermistor selections (for thermistor measurements), whether or not a reversal measurement is selected, the number of measurements, the settling time, and the number of DVM readings to average. Also, from the Measurement Options Screen, the delay between measurement runs is displayed here.

- **PROGRAM INFO:** The program information drop-down menu displays the active program along with the program elements (ie. the resistors being measured within the program).

Below the drop-down menus are the **Temperature**, **Pressure**, and **Humidity** readings for the lab environment. Values are displayed in these information boxes only if a Rotronic AM3 temperature / humidity device and / or a Mensor 15000 Barometer is connected to the system. These devices must also be activated in the Setup Menu Screen.

More information boxes reveal information about the **HI** and **LO** resistors. These include: the manufacturer / model number **(HI & LO)**, the serial number **(Serial #)**, and the nominal value **(Value)**. The **Value** box for the unknown resistor is continuously updated as more measurements are performed.

> NOTE: **During a measurement, either the HI or LO information box will be highlighted (blue) to indicate the reference resistor.**

To the left of the **HI** and **LO** information boxes, the mean ratio **(Mean)**, standard deviation of the mean **(Std. Dev.)**, and uncertainty **(Uncert.)** boxes are also continuously updated as measurements are displayed in the Measurement Table.

Since the measurement sequence is not immediate, the user can observe that the measurement is taking place by the commands at the top of the screen. To determine what stage the measurement is at, the **Program ID** information box displays which potential terminal of which resistor it is measuring. The 6000A

Software measures four potential points to obtain the ratio of the two resistors: HI P2, HI P1, LO P1, LO P2. Therefore, the **Program ID** box displays these steps with *"U"* being the **HI** resistor and *"L"* being the **LO** resistor. The **Voltage** is also displayed at each step in the appropriate information box.

The temperature information box **(Temp.)** at the lower right corner of the Main Menu Screen is used to display temperature for thermistor measurements. This is explained further in Section 5.2.

5.1.2 Measurement Table

The lower left portion of the Main Menu Screen displays a Measurement Table showing the ratio values as they are calculated. The Measurement Index above the Measurement Table indicates the number of the measurement currently being performed.

For reversal measurements, the Measurement Table also displays the reversal ratio and standard deviation. Therefore, to distinguish reversal measurements from regular measurements, an *"R"* is added to the measurement number in the Measurement Table.

ie. the measurement numbers in the Measurement Table will display *"1"*, *"1 R"*, *"2"*, *"2 R"*, *"3"*, *"3 R"*, etc.

After measurements are completed, the **"Arrow"** keys below the Measurement Table may be used to view previous results. If a combined program was just completed, pressing the left and right arrow keys displays the Measurement Table and graph for a specific individual program within the combined program. If multiple measurement runs were performed, the up and down arrow keys display the Measurement Table and graph for different measurement runs.

NOTE: These arrow keys can only be used once all measurements are completed.

5.1.3 Plotting the Measurements

During a measurement run, as the ratio values are displayed in the Measurement Table, the resistance values of the unknown resistor are plotted to the graph. As more points are plotted, the axes of the graph are modified so as to maximize the plotted points to allow the user to focus on the relationship between the points. The mean, minimum, and maximum resistance values are displayed below the graph and are continuously updated as more points are plotted.

> NOTE: **For reversal measurements, the resistance obtained from the reversal is also plotted to the graph.**

The graph may be modified at any time during measurements or after measurements are completed. This is done by the drop-down menus:

- **Graph Lines:** This option allows the user to observe the best-fit curve, the standard deviation of the plotted points, or both.

- **Graph Span:** This option controls the x-axis of the graph by selecting the number of measurements to view. To obtain the mean resistance of the last 10 measurements, set the Graph Span to *"Last 10"* to eliminate all but the last 10 readings from the graph. The mean value below the graph indicates the mean resistance value within that graph span. This option gives the user an accurate view of the points within a specific interval.

The **Decimal Display Resolution** drop-down menu changes the resolution of the measurement values in the Measurement Table. If the resolution is set to *"9"*, the next ratio and standard deviation value in the Measurement Table will be displayed to nine decimal places.

5.2 Performing a Thermistor Measurement

The 6000A system is also capable of performing thermistor measurements to obtain temperature corrected resistance values for an unknown resistor. The procedure is quite similar to resistance measurements with a few slight changes.

Like resistance measurements, data files must be selected upon initialization of the 6000A Software (Setup, Resistor, Program). The Setup file contains the same information for both resistance and thermistor measurements. The Resistor Menu Screen, however, requires that the thermistors be entered (just like a resistor) with "a", "b", and "c" constants obtained from the thermistor's calibration report (refer to Section 3.5.1). The data boxes for these constants are displayed when *"Thermistor"* is selected as the *"Resistor Type"*. The Program Menu Screen requires that a thermistor be selected when creating a measurement program (refer to Section 3.6.2).

Once initial settings are complete, thermistor measurements may begin. Ratio measurements are displayed in the Measurement Table and resistance values are plotted in the graph in much the same way as for resistance measurements (refer to Figure 21).

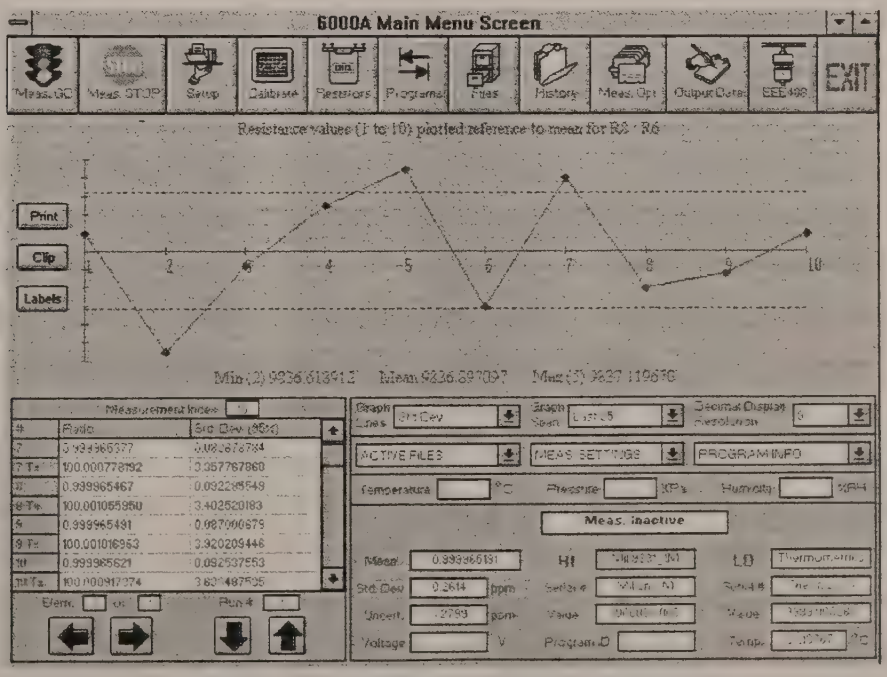


Figure 21 ... Thermistor Measurement Run

The 6000A Software allows for three thermistor cases:

1. *A thermistor is measured directly against a 1 MΩ resistor.*
2. *A thermistor is connected to either the reference or unknown resistor.*
3. *A thermistor is connected to both the reference and unknown resistor.*

First of all, a thermistor may be measured directly against a 1 MΩ resistor. To indicate that a thermistor is being measured, a *"T"* is added to the measurement number in the Measurement Table (ie. the measurement numbers will display *"1 T"*, *"2 T"*, *"3 T"*, etc.). For each measurement, the temperature information box **(Temp.)** in the lower right corner of the Main Menu Screen will display the temperature of the thermistor and the resistance of the thermistor will be plotted in the graph.

The second case involves a thermistor connected to either the reference resistor or unknown resistor. In this case, the 6000A Software measures the unknown resistor against the reference resistor to obtain a ratio and a temporary resistance value for the ESI resistor. Next, the thermistor is measured against a 1 MΩ resistor to obtain a resistance value for the thermistor, which is then converted to temperature using the Steinhart-Hart Equation. This temperature is used to correct the resistance of the ESI resistor. The Measurement Table will display the ratio for both measurements, with *"Ts"* indicating the thermistor was connected to the reference resistor and *"Tx"* indicating the thermistor was connected to the unknown resistor. The graph plots the final temperature corrected resistance value of the ESI resistor.

Finally, the third case involves a thermistor connected to both the reference resistor and unknown resistor. In this case, the 6000A Software measures the unknown resistor against the reference resistor to obtain a ratio. Next, the reference thermistor is measured against a 1 MΩ resistor to obtain a resistance value for the thermistor, which is converted to temperature and used to correct the resistance of the reference resistor. This corrected reference resistance is used in the next measurement where the unknown thermistor is measured against a 1 MΩ resistor. The unknown thermistor resistance value obtained is also converted to temperature and used to correct the resistance of the unknown resistor. The Measurement Table will display the ratio for all three measurements, with *"Ts"* indicating the reference thermistor and *"Tx"* indicating the unknown thermistor (ie. the measurement numbers will display *"1"*, *"1 Ts"*, *"1 Tx"*, *"2"*, *"2 Ts"*, *"2 Tx"*, etc.). The graph will plot the final temperature corrected resistance value of the unknown resistor.

5.3 Exiting the Software

To exit the 6000A Software, select the menu key entitled **EXIT** from the Main Menu Screen. A message will then be displayed reminding the user to save any resistor changes to a file for future use (refer to Figure 22).

Select **Yes** to exit the 6000A Software and return to Windows.
Select **No** to return to the Main Menu Screen for further measurements.

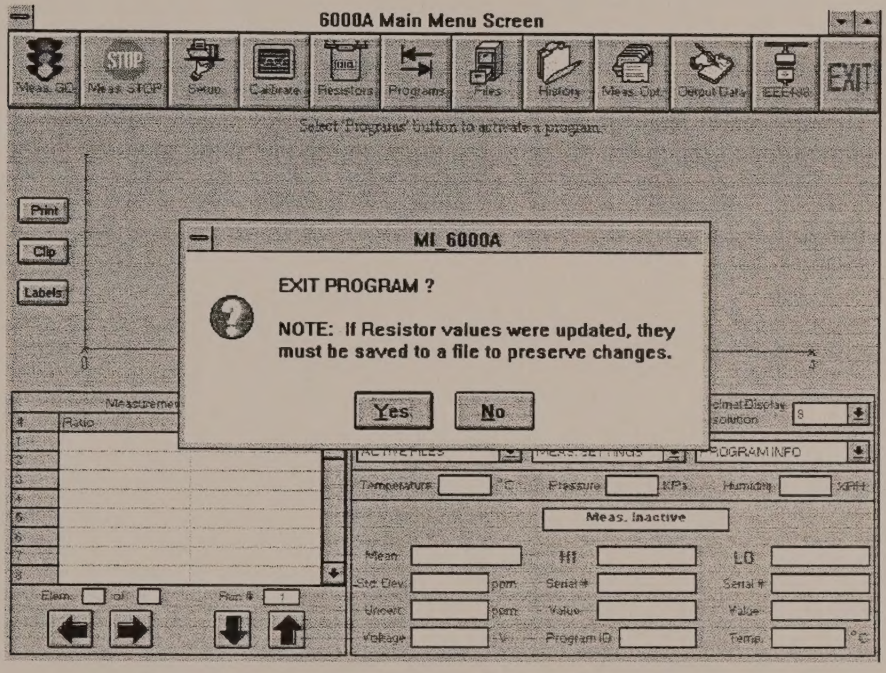


Figure 22 ... Exit Software Screen

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